Office of Naval Research
European Office
91-03

# ESN INFORMATION BULLETIN

European Science Notes Information Bulletin
Reports on Current
European/Middle Eastern Science

# Office of Naval Research European Office

TELEPHONE: 44-71-409 + ext.
TELEX: (900) 7402119 ONRE UC
FAX: 44-71-724-7030/723-1837
OMNET: ONR.EUROPE
MILNET: ONREUR@ONREUR-GW.NAVY.MIL

## Office of the Commanding Officer and Scientific Director

| Code | Ext. | | |
|---|---|---|---|
| 00 | 4417 | Commanding Officer | CAPT Victor L. Pesce |
| 01 | 4508 | Scientific Director | Dr. James E. Andrews |

## Liaison Officers and Liaison Scientists

| | | | |
|---|---|---|---|
| 11 | 4478 | Acoustics/Structural Acoustics | Dr. David Feit |
| 12 | 4539 | Mathematics | Dr. Robert D. Ryan |
| 13 | 4539 | Materials Science | Dr. Michael J. Koczak |
| 16 | 4478 | Computer Science/Computer Engineering | Dr. Miroslaw A. Malek |
| 17 | 4539 | Biochemistry/Microbiology | Dr. Keith E. Cooksey |
| 19 | 4413 | Aerospace Systems Technology | CDR Dennis R. Sadowski |
| 20 | 4413 | Surface Weapons Systems Technology | CDR Barth J. Root |
| 21 | 4131 | Oceanography | LCDR Larry Jendro |
| 22 | 4260 | Undersea Warfare Systems Technology | CDR John A. Sampson |
| 23 | 4471 | Ocean/Atmosphere | Mr. Hans Dolezalek |
| 24 | 4539 | Solid-State Chemistry and Physics | Mr. Howard Lessoff |
| 25 | 4478 | Energetic Materials | Dr. R.W. Armstrong |
| 26 | 4539 | Ocean Acoustics | Dr. R.L. Martin |

U.S. Mail Address
Box 39
FPO New York 09510-0700

U.K. Address
[redacted]

# REPORT DOCUMENTATION PAGE

| | |
|---|---|
| 1a REPORT SECURITY CLASSIFICATION<br>UNCLASSIFIED | 1b RESTRICTIVE MARKINGS |
| 2a SECURITY CLASSIFICATION AUTHORITY | 3 DISTRIBUTION/AVAILABILITY OF REPORT<br>Approved for public release; distribution unlimited |
| 2b DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4 PERFORMING ORGANIZATION REPORT NUMBER(S)<br>91-03 | 5 MONITORING ORGANIZATION REPORT NUMBER(S) |
| 6a NAME OF PERFORMING ORGANIZATION<br>Office of Naval Research<br>European Office<br>6b OFFICE SYMBOL (If applicable)<br>ONREUR | 7a NAME OF MONITORING ORGANIZATION |
| 6c ADDRESS (City, State, and ZIP Code)<br>Box 39<br>FPO, NY 09510-0700 | 7b ADDRESS (City, State, and ZIP Code) |
| 8a NAME OF FUNDING SPONSORING ORGANIZATION<br>8b OFFICE SYMBOL (If applicable) | 9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER |
| 8c ADDRESS (City, State, and ZIP Code) | 10 SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO |
| 11 TITLE (Include Security Classification)<br>European Science Notes Information Bulletin – (UNCLASSIFIED) | |
| 12 PERSONAL AUTHOR(S)<br>Ms. Connie R. Orendorf, Editor | |
| 13a TYPE OF REPORT<br>Multidiscipline<br>13b TIME COVERED FROM _____ TO _____<br>14 DATE OF REPORT (Year, Month, Day)<br>April 1991<br>15 PAGE COUNT<br>89 | |
| 16 SUPPLEMENTARY NOTATION | |

| 17 COSATI CODES | | | 18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | |
| | | | |
| | | | |

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The European Science Notes Information Bulletin (*ESNIB*) 91-03 is a compilation of reports on recent developments in European science of specific interest to the U.S. research and development community, and is issued in support of the mission of the Office of Naval Research European Office (ONREUR). Issue Number 91-03 in addition to European area news, notes, and abstracts, contains reports in the fields of Acoustics, Atmospheric Electricity, Computer Science, Materials, Physics, and Psychology. The value of the *ESNIB* to Americans is to call attention to current activity in European science and technology and to identify the institutions and people responsible for these efforts. The *ESNIB* authors are primarily ONREUR staff members; other reports are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the U.S. Army Research, Development and Standardization Group. Scientists from the U.S. who are traveling in Europe may also be invited to submit reports.

| | |
|---|---|
| 20 DISTRIBUTION/AVAILABILITY OF ABSTRACT<br>☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS | 21 ABSTRACT SECURITY CLASSIFICATION<br>UNCLASSIFIED |
| 22a NAME OF RESPONSIBLE INDIVIDUAL<br>Ms. Connie R. Orendorf | 22b TELEPHONE (Include Area Code)<br>(44-71) 409-4340<br>22c OFFICE SYMBOL<br>310 |

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete



☆ U.S. Government Printing Office: 1988—607-044

# ESN INFORMATION BULLETIN

91-03

This publication is approved for official dissemination of technical and scientific information of interest to the Defense research community and the scientific community at large.

Commanding Officer ..... CAPT Victor L. Pesce, USN
Scientific Director ..... James E. Andrews
Editor ..... Ms. Connie R. Orendorf

## ACOUSTICS



The author discusses an unconventional energy source found in some ocean environments--natural gas clathrates.

## ATMOSPHERIC ELECTRICITY



This laboratory concentrates on the investigation of atmospheric ions, aerosol, and atmospheric electric conductivity.

## COMPUTER SCIENCE



The main objective of this workshop was to stimulate a search for catalysts that would facilitate cooperation between applications experts and computer architects in designing and implementing a new generation of parallel computers.



The information presented at this conference spanned a large range--from systems for doing machine translation to unification phonology.

## MATERIALS



The Office of Naval Research sponsored a small workshop attended by 12 representatives of industry, research laboratories, and universities. The delegates represented seven countries. They discussed consensus on the present state of research in metal-matrix composites, relevance of this state of research to the needs of industry in Europe and the U.S., and priorities for future research.

## PHYSICS



## PSYCHOLOGY



## NEWS, NOTES, AND ABSTRACTS

# ACOUSTICS

## Natural Gas Clathrates: Arctic and Nordic Sea Potential

*Michael D. Max, Acoustics Division, Naval Research Laboratory, Washington, D.C.*

### Introduction

This contribution is a summary of a paper presented at a meeting of the Norwegian Petroleum Society, August 14-18, 1990, at Tromsø, Norway. I will not present references and details here.

### Natural Gas Clathrates

Clathrates (gas hydrates) are medium- to high-pressure-stabilized, ice-like compounds that form under the influence of ambient pressure found in the cold, deep-ocean environment, especially the polar oceans. Natural gas, primarily methane, is held within a water molecule crystal lattice and thermodynamically stabilizes the structure through hydrogen bonding.

Clathrate forms in the clathrate stability zone (CSZ) in which it is thermodynamically stable. The CSZ extends downward from the sediment surface to a depth determined by local heat flow and sedimentation rate conditions. The CSZ's lower part can become solid and can act as a gas trap. The CSZ's base is the pressure-temperature phase boundary of the gas + water/clathrate reaction. From 180 to 200 volumes of gas can be concentrated in one volume of clathrate. Clathrate formation and trapping of gas as a long-term part of marine basin genesis is a first-order concentration process that can hold immense volumes of gas in marine sediment.

The clathrate layer is a steady-state, aggrading phenomenon in which gas produced in or below sediment becomes fixed in the zone of clathrate stability in the uppermost sediments. The upper surface of the clathrate is commonly near or at the sea bottom below 200-400-m water depth. Polar clathrates are up to 1700-m thick on land. On continental shelves and in the deep ocean, clathrates up to 1100-m thick have been identified. At constant geothermal gradients, the thickness of the clathrate stability zone increases with increased water depth and increased pressures. For example, a single, long seismic line near the Blake Outer Ridge (Southeastern U.S.) clearly images the gas hydrate horizon. This thins from almost 1 sec of two-way travel time (twt) at a water depth of slightly greater than 6 sec of twt to less than 0.2 sec twt at a water depth of about 0.5 sec twt.

The clathrate blanket can form because there is a thermal balance between the pressure-temperature conditions of the clathrate stability zone, rising heat, and transfer of the heat energy into the water column at the ocean bottom. To keep the thermodynamic system in balance, the base of the clathrate moves upward as sedimentation proceeds. Where clathrate at the base of the layer becomes unstable because of temperature rise from upward migrating heat, it inverts to gas and tends to rise back into the clathrate stability zone. This long-term process of gas concentration means that whatever gas is produced in oceanic sediment and migrates into the uppermost part of the sediment column is concentrated in the clathrate stability zone or in gas pools below it. Only gas that bursts the clathrate layer can normally escape through a clathrate cap. We do not fully understand the mechanisms of this bursting process.

### Arctic Ocean

The Arctic Ocean is a unique ocean basin in many respects. Besides being largely ice-covered the year round, it is the largest sea that is almost completely surrounded by upstanding continental crust. There are only shallow or narrow passages in the Bering Strait, the Nares Strait, and passages between Canadian Arctic islands, and between the Fram Strait and Barents Sea. The Arctic Ocean exhibits a long and complex history that is in part related to terrain accretion against the Pacific Ocean and formation of internal oceanic crust. The most recent development is the northward propagation of the Atlantic Plate margin into the eastern Arctic along the Arctic Midocean Ridge. The Arctic Basin contains older seafloor in its Alaskan-Siberian end where the present ocean/continent boundaries were established before those along the Greenland/European end. Sediments in continental rise and slope prisms are thus not equally extensive and complex.

We do not understand the Arctic Basin in detail because ice cover and accessibility have made surveying difficult and expensive. Bathymetric data is meager and unevenly distributed. Sediment descriptions are restricted and only the surface sediment is known in the deep basin. Exploration drilling has occurred only along segments of the Alaskan and Canadian coastal plains. Hydrocarbon exploration in the Barents Sea has not yet reached to the northern margin of the shelf. Exploration in the Siberian shelf has not yet reached offshore. Even north of the productive eastern Siberian gas field, preliminary exploration of the southern Kara Sea is only beginning. Seismic data, both reflection and refraction, is almost nonexistent except within recognized shelf petroleum provinces.

The floor of the Arctic Ocean consists of a series of roughly parallel ridges and basins extending from the North American Continent to the Eurasian Supercontinent. Basins are generally sediment covered, especially adjacent to the continents. Each basin is directly adjacent to both land masses and some basins are influenced by continental sedimentation from more than one continent. Abyssal plain physiography appears to characterize basin floors. Both core and geophysical information shows that carbonate deposition from pelagic processes occur along the bathymetrically shallow ridges. Terrigenous sediments, mainly gravity-driven turbidites, probably dominate the sedimentary successions along the basins. Superimposed on the normal near-continent marine sedimentation, however, are glaciomarine sediments, which dominate the present sediments. Sediment thicknesses are variable. The thicker sediments in the Canada Basin lie between Asia and North America; thinner sediments lie between the North Pole and the Barents Sea shelf.

## Nordic Sea

The Nordic (Norwegian/Greenland Sea) extends from Iceland to the Fram Straits and can be divided into several tectono-sedimentary provinces. These provinces are controlled by the transform-ridge system in the oceanic crust. Between Iceland, which straddles Greenland/Iceland/U.K. ridge, and the Jan Mayen Fracture Zone, there is a strong asymmetry with the extinct spreading center of the Aegir Ridge subsiding in the Norway Basin (east) and the rougher present spreading center of the Kolbeinsey Ridge (west). Sediments immediately north of Iceland are up to 1-km thick but thin rapidly to less than 200-m thick in ponded areas along the remainder of the Kobiensey Ridge to the Jan Mayen Fracture Zone. Quaternary sediments on the southeastern Greenland margin are up to 2.5-km thick and overlie up to 4 km of Tertiary and Mesozoic sediments. Sediment is thin in the eastern part of the Iceland-Jan Mayen segment but thickens along the Norway Basin (east). Thin sediment buries the extinct Aegir Ridge, which separates more thickly sedimented areas. Sediments on the Jan Mayen Ridge are up to 3-km thick. The Jan Mayen fragment is anomalous in that it is thickly sedimented and underlain by thinned Greenland continental margin. Jan Meyen's midocean isolation was caused by the ridge jump from the Aegir to the Kolbeinsey Ridge.

## Distribution of Clathrates

Clathrates have been recognized in Arctic and North Atlantic continental slopes and in continental rise sediments, but their presence has not been substantiated in abyssal depths. On continental shelves, clathrates are found most commonly in sedimentary basin provinces, although they may be found in thinly sedimented areas where gas can be introduced. Gas hydrates have been identified as potential economic deposits on the Alaskan North Slope.

Sediments with high enough organic contents that could have sourced gas occur in the older parts of the basins, mainly along continental margins. Younger oceanic crust areas are usually associated with thin sediments. These crust areas are principally along the axes of the active plate margin extending from Iceland to the Laptev Sea continental slope. Each margin and many of the internal basin areas, however, have unique geological histories and sediment thickness character.

## Zonal Areas of Clathrate Development

Natural gas clathrates (hydrates) probably occur over broad areas of the Arctic Ocean and northern Nordic Sea. By analogy with identification elsewhere, shallow free gas reservoirs can be expected within 1.5 km of the sediment surface. Clathrate and trapped gas in thickly sedimented areas in the Arctic and Nordic seas have been identified locally in the west Barents Sea and northern Alaska continental margins. These estimates reflect areas in water depths greater than 500 m where sediment thickness exceeds 3 km. The sediment thickness which can be expected to source significant gas under the influence of normal heatflow. The area and volumetric estimates presented here are, of course, speculative. However, they demonstrate the methodology for identifying the liklihood of gas generation and clathrate distribution. Three separate types of areas are identified (see Figure 1) in which the local geological/bathymetric contours are inherently different:

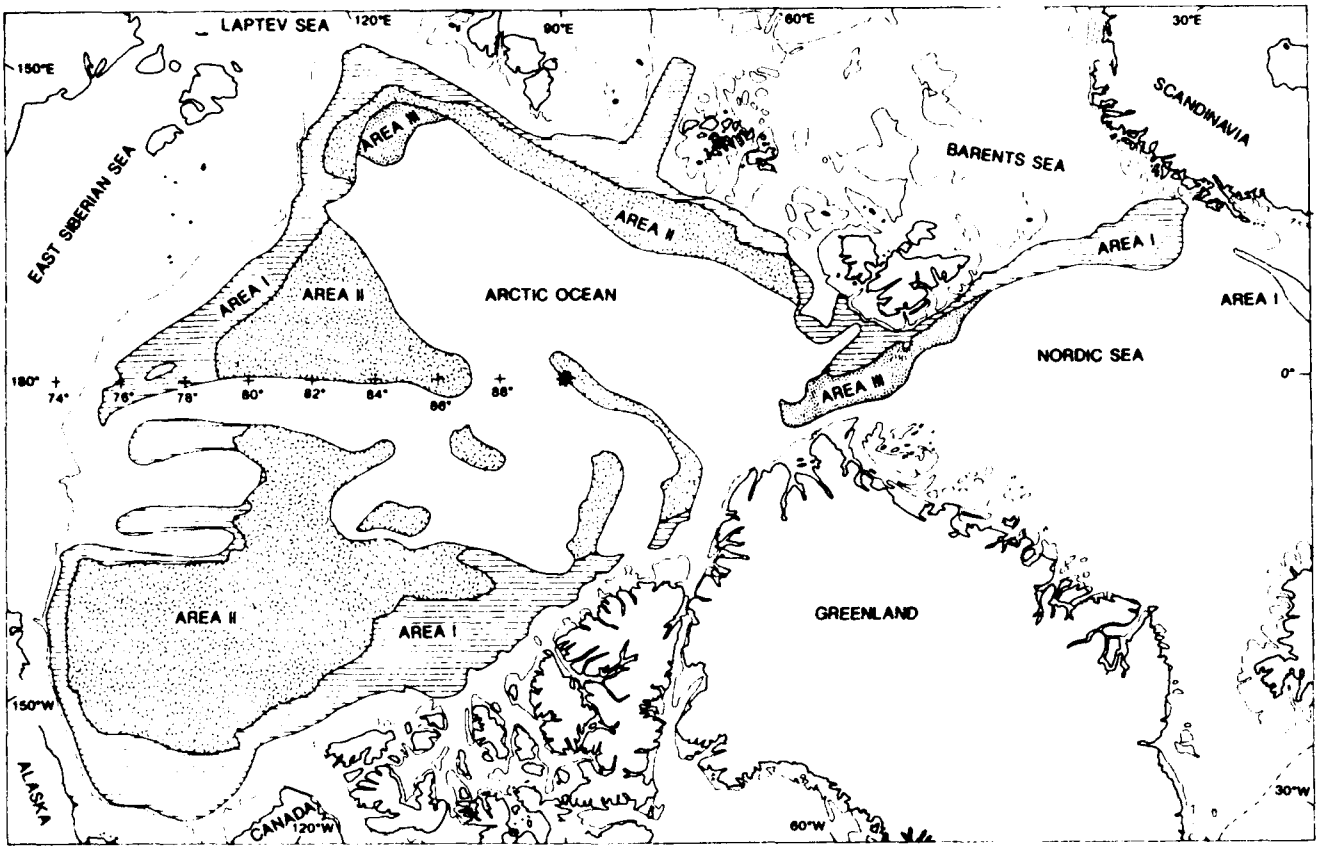



**Figure 1. Clathrate likelihood areas**

Slope and abyssal areas are separated in Arctic at about the 3,000-m contour. The 2,500-m contour is used in separating Wrangel Abyssal Plain from East Siberian Sea continental margin; there are no abyssal areas in Nordic Sea. Sediment thickness data are not included for areas south of broken line passing across southern Iceland. Area I. Continental slope areas between 500- and 3,000-m are following recognized clathrate development in continental slope north of Alaska where sediment thickness exceeds 3 km. Area II. Abyssal areas and sedimentary basins are not tied to continental shelf structure where sediment thickness exceeds 3 km. Area III. Areas of abnormally high heatflow are associated with plate margin where gas could be sourced from thin sediments or where juvenile gas from volcanic exhalation could be trapped within the CSZ in overlying sediment. In Area III are minimum sediment thickness of between 0.75 - 1 km in ridge vicinities.

**Area I.** This area shows continental slopes between 500- and 3,000-m water depth where sediment thickness is greater than 3 km. This conforms with the water depth range in which clathrates have been identified in the region, particularly in the Northern slope of Alaska margin. We used 3,000-m rather than the 2,800-m maximum depth of bottom simulating reflector (BSR) recognition because this was the nearest available contour for the region and clathrate has been shown to extend beyond good BSR. In effect, this zone extends the currently recognized clathrate throughout the region in similar tectonosedimentary/water depth environments. Arctic geologists (U.S. Geological Survey) have estimated that about 700,000 km$^2$ of clathrate bottom occur in the Arctic in an area about coincident with Area I. Using new sediment thickness maps, we estimate that about 817,543 km$^2$ of the Arctic Basin, and about 154,406 km$^2$ of the Nordic Sea basin are of high clathrate potential.

The Svyataya Anna Trough, given the unlikely circumstance of oceanic crust heatflow values, has about 50,118 km$^2$ of clathrate likelihood area below the 500-m contour. The Svayataya Anna Trough is included only because its bottom lies below the 500-m contour. Realistically, it should be considered as similar to the Bear Island Trough which is almost 500-m deep, and is excluded because it is not a deep ocean area.

**Area II.** The area shows abyssal regions below 3,000 m (except in the continental slope-ward margin of the Wrangel Abyssal Plain where the 2,500-m contour has been mainly used) where sediment thickness is greater than 3 km. Likelihood of clathrate development is based on analogy with other abyssal areas where clathrate has been identified. In Arctic abyssal areas, no identifications of clathrate have yet been made, but this is probably because of the lack of suitable seismic data rather than proof of barren character. Abyssal plains are known as being more reflective to acoustic energy than

can be estimated from acoustic interaction modeling of sediments with no clathrates, and the presence of clathrate could account for this discrepancy. Clathrates have also been tentatively identified in the Argentine Basin, which is swept by the cold Antarctic Bottom Water current. It is likely that clathrates also occur in Arctic and Nordic Sea abyssal areas where similar gas-generating factors prevail. About 1,402,819 $km^2$ of suitable abyssal plain area occurs in the Arctic.

**Area III.** Two relatively small areas of the thickest of otherwise thin sediment overlays active transform/ridge systems. In these systems, it is known that gas and hot hydrothermal fluids are generated as a by-product of magmatic and volcanic activity at the plate margin. In these areas, possibly juvenile gas or gas generated by hot hydrothermal solutions within the sediment has been trapped in sediment that would otherwise be too thin to have generated significant gas. This unit is the most speculative of the three. The 1-km sediment isopach has been used to define these areas but thinner sediments could also hold significant clathrate, if abundant gas were pumped into these deep-water areas where the CSZ potential is the most stable and thick. About 34,931 $km^2$ of the Arctic Basin and about 79,986 $km^2$ of the Nordic Sea basin are underlain by these areas.

## Clathrate and Natural Gas Volumes

Six criteria have been used in estimating clathrate potential:

1. Estimates reflect only the potential volumes of natural gas held as clathrate in the CSZ. No estimates are made for gas trapped below clathrate, which in all likelihood will provide the first economic targets because their occurrence is site-specific and dependent on individual evaluation. Gas trapped below clathrate will be pressurized depending on water depth and lithostatic load. Such pressurization will cause potential field volumes to be large with respect to their volume, especially considering that gas in the reservoir must be recharged by inverting clathrate at the base of the cap.
2. Average thickness for the CSZ of 450 m in Area I and 700-m in Areas II and III have been used because any sliding scale of thickness versus water depth would involve very complex calculations that would be difficult to compare with later using different criteria. Using 450-m biases, the calculations toward the base of the CSZ because over 50 percent of the clathrate in the CSZ will occur in the lower half. These figures are based on the water depth--depth of clathrate in sediment calculated by using an an admittedly low average Vp for the CSZ of 2,000-m/sec.
3. Based on the amount of clathrate that can be anticipated in a sediment with 40 percent porosity and 12 percent overall pore space filling, a volumetric estimation indicates that about 5 percent of the CSZ is likely to be clathrate. This estimate conforms with current Department of Energy practice for continuity and allows for comparison. This may be more conservative than recent U.S. Geological Survey calculations.
4. A 180:1 gas volume has been used for the clathrate to give 1 ATA (1 atmosphere pressure or 14.7 psi) gas volumes for clathrate. Conversion from 1-$m^3$ of clathrate to 180-$m^3$ of gas is carried out at 1 ATA.
5. No conductivity blanketing effects of clathrate have been considered because of the difficulty of predicting effect from place to place. No heat transfer by hydrothermal fluid cells has been modeled.
6. Gas migrating into the CSZ from below is trapped in the CSZ.

Analysis of sediment thickness, sediment types, sedimentational history, and heat flow suggests that widespread generation of gas has been trapped in, and possibly below, impermeable clathrate over 1.5x106 $km^2$ of the Arctic and Atlantic polar region.

Potential volume of methane in clathrate in Arctic Area I is 3,310,920 $km^3$; Arctic Area II is 5,302,692 $km^3$; Arctic Area III is 219,960 $km^3$. Nordic Sea Area I volume is 625,338 $km^3$; Area III is 324,000 $km^3$; there is no Area II. Using these criteria, total volume in which there is a good likelihood for clathrate development in this region is 8,833,572 $km^3$ for the Arctic and 949,338 $km^3$ for the Nordic Sea. Clathrate can be expected to occur in sediments of most of the Canada and Wrangel Basins, and along most of the continental slope and rise sediments. If clathrate is developed over the predicted regions, they could hold over 8x106 $km^3$ of natural gas.

## Implications of Clathrate and Gas Development and Distribution

Many countries that border ocean areas (such as Japan) that were perceived as having no hydrocarbon potential because of narrow continental shelves, unsuitable basin formation, and sedimentological history (or a highly volcanic character) may be able to extract gas from nearby clathrates. Well-developed clathrates, which from the impedance character appear to trap gas in significant closures, occur in the continental slope east of Japan. Furthermore, clathrate appears to be a common constituent of accretionary prisms from Chile to Japan. The economic and political aspects of new ocean energy sources will be of considerable interest to nations

adjacent to continental margins and ocean basins that have no historical national petroleum (oil) resources. In addition, much of the probable clathrate resources probably occurs outside of currently declared national economic zones (see Figure 2).

flow from major producing regions) and environmental considerations (such as emissions from combustion) may force an earlier transition to the gas economy than could be predicted from an economics analysis alone. Thus, the shift from oil to gas as the primary nonnuclear power

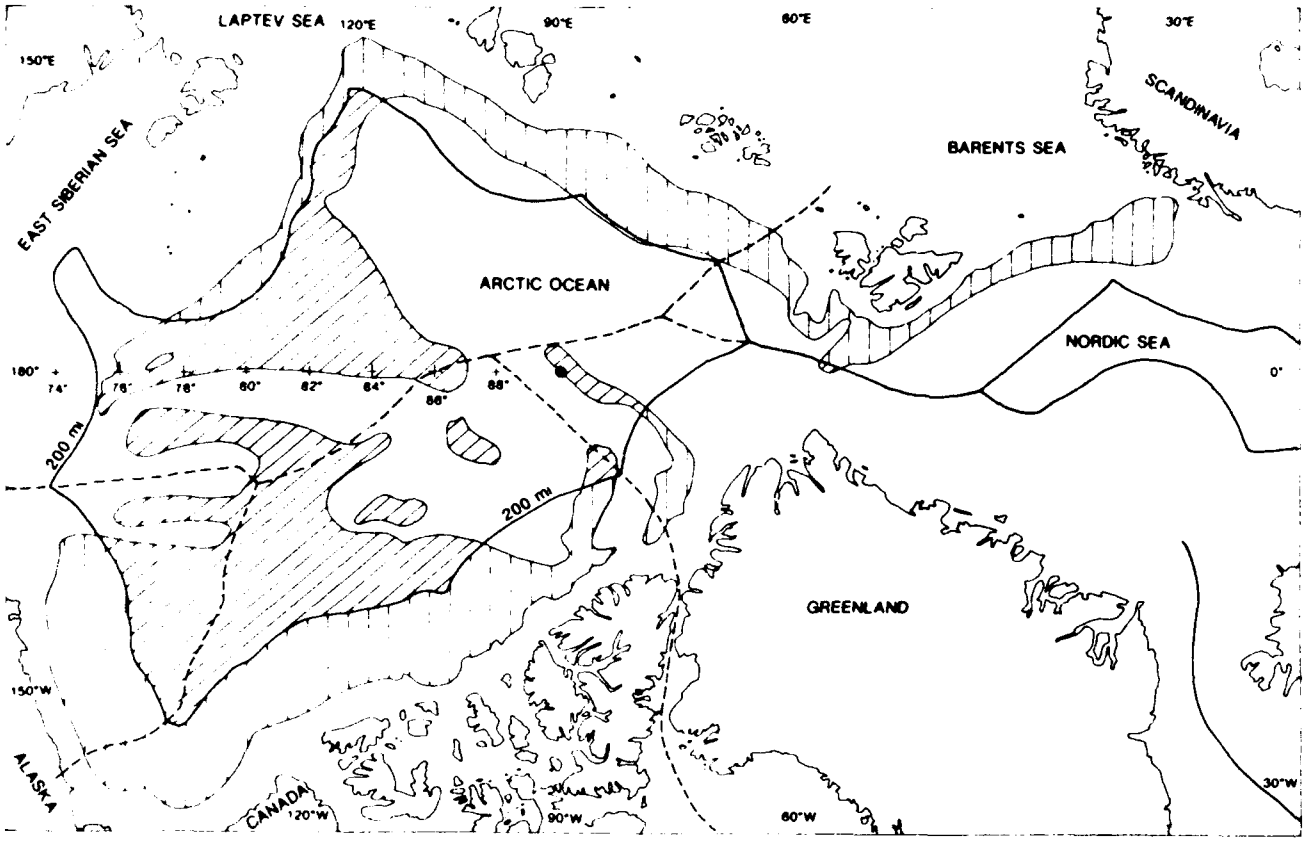



**Figure 2. Simplified clathrate likelihood areas**

Heavy line shows current EEZs in the northern polar region. Vertical lines indicate clathrate likelihood areas within EEZs; diagonal, more closely spaced lines indicate clathrate likelihood areas outside of EEZs.

## What Does All This Mean?

Even with no disruptions of the world economy, the economic energy base must shift from oil to gas in the course of the next quarter century or so. Geopolitical considerations (such as significant pertabation of the oil

source is a matter of concern today, not an obscure concern of the future. We must begin to master the ocean environment because we must descend into it to extract and utilize this unconventional energy resource--natural gas clathrates.

# ATMOSPHERIC ELECTRICITY

## Air-Electricity Laboratory--Tartu, Estonia

*by Hans Dolezalek, a physicist serving as Liaison Scientist at the Office of Naval Research European Office, London. He is currently specializing in remote sensing (with emphasis on the ocean), and questions about applications of atmospheric electricity for global change. Before this assignment, he acted as a Scientific Officer of the Remote Sensing Program in the Ocean Sciences Directorate, Office of Naval Research Headquarters, Washington, D.C.*

### Introduction

The University of Tartu (University), located in Tartu (also known as Dorpat), Estonia, was founded in 1632 by the Swedish King Gustavus Adolphus and was first governed by the former chancellor of the University of Uppsala. The University quickly acquired (and enjoyed for a long time) an excellent scientific reputation in Europe and the Russian Empire. Suspended from 1711 to 1802, the University now constitutes the scientific and humanistics center of the Republic of Estonia. The reputation of the University has spread well beyond the borders of this small country.

The Air-Electricity Laboratory (Laboratory), directly reporting to the Vice Rector of the University, was essentially formed, and is now led, by Professor Hannes Tammet. Professor Tammet is well known for his theoretical and experimental capabilities. He is the author of the basic modern book on the measurement of atmospheric ions (Tammet 1970). Professor Tammet is the Vice-President of the International Commission on Atmospheric Electricity (International Association of Meteorology and Atmospheric Physics [IAMAP]/Union de Géodésie et Géophysique Internationale {International Union of Geodesy and Geophysics [UGGI]}/International Council of Scientific Unions [ICSU]).

The Laboratory is among the leading ones in its scientific domain; in some regards, it is certainly the leading one. Its series of publications in the Acta et Communicationes Universitatis Tartuensis is very long. The scientific domain encompasses the following three main topics as well as many other smaller ones:

1. Research on the physics and chemistry of atmospheric ions, especially ions of a middle age (which turns out to be about one second)
2. Research on physics and chemistry of "natural" ions in the atmosphere
3. Research on aerosol electricity and atmospheric aerosol.

The emphasis is on the fundamental physical/chemical processes. This is not only welcome but also urgently needed. Without a satisfactory understanding of these processes, wrong decisions in the applied field can hardly be avoided. Such decisions could have large consequences for the interpretation of the results of some Global Change[1] monitoring efforts.

The Laboratory has 14 scientists presently working on the main topics. One scientist is performing research in a field station in a practically unpolluted area, Tahkuse, about 100 km west/northwest of Tartu. Four other scientists are occupied with different problems in the same scientific domain.

Although the Laboratory is in some aspects the leading institute in the world, there are shortcomings. For instance, the Laboratory does not have the very large and expensive modern mass-spectroscopy instruments. However, the Laboratory has overcome most of the disadvantages of this situation; but compared to some western institutes, there are still some shortfalls. Another handicap is the lack of sophisticated and reliable computers. The Laboratory's many computers are less powerful and break down often. These problems are common in that area of the world. In spite of these problems, very good experimental work is performed which shows the high quality of researchers.

Of the three main topics, the experimental work on Topic 1 is done in a university building in Tartu; for Topic 2, the measurements are performed in Tahkuse; while for Topic 3, measurements are done in Tartu and on

[1] An umbrella for all present efforts to monitor and evaluate the potential for world-wide climatic change partially caused by human activities. The "greenhouse" effect, ozone hole, ocean warming, are part of Global Change.

expeditions (for example, to Voore in Estonia, Preila in Lithuania, and Zvenigorod in Russia). I will provide brief descriptions of the main research topics and discuss their results.

## Research on the Physics and Chemistry of Atmospheric Ions, Especially Ions of a Middle Age

Many investigations of artificially created ions have been conducted. These ions were investigated as quickly as possible after they came into existence because the main scientific interest was to determine their primary nature. Of the many papers on this subject, I quote only Huertas and Fontan (1983) because some of their diagrams are well known after publication in the Handbook of Chemistry and Physics (see; e.g., Weast 1986). An interesting exercise is to follow the development of these ions over some time to discover whether they approach an equilibrium state. About 25 years ago, the U.S. Army began a rather large program to measure the mobility spectra of atmospheric ions in the mesosphere. The program was abruptly canceled because of the assumption that the nature of these ions may change very quickly and frequently. While this is basically true, information on possible equilibrium states might have modified this assumption; we still know little about this. According to the scientists at the Laboratory, an interesting state is that of ions that are of an age of about one second. That is what they are now investigating.

Likewise, in spite of several investigations, the influence of chemical admixtures to the atmosphere on the nature of ions is only partially known. "Only fragments and parts of possible reactions have been investigated, whereas a considerable number of thermodynamic characteristics of reactions in the gas phase are not known" (T. Parts 1990, quoting De Puy and Bierbaum 1987).

Present investigations at the Laboratory are dealing with mobilities between

$$0.5 \text{ and } 2.0 \times 10^{-4} \quad m^2 V^{-1} s^{-1};$$

i.e., with the range of fast ions. Pressure, temperature, relative humidity, and the composition of the atmosphere (deliberately controlled by admixture of various chemicals in amounts which are relatively measured) are changed. Then the mobility spectrum of ions of an age of about 1 second is recorded. More than 1,000 of such spectra have been obtained. Composition of fast ions may depend on very small admixtures to air. Ion spectroscopy is known as a promising technology for environmental measurements (Brokenshire and Pay 1989). In generally known instruments, ions with an age of 10 milliseconds are investigated. The sensitivity is proportional to ion age in these ranges. Aspiration spectrometers designed at the Laboratory can detect trace gases in concentrations about 100 times lower than possible in the drift tubes used elsewhere. For a practically useful interpretation of ion spectra, we need a lot of knowledge on the influence of various pollutants. Therefore, obtaining this knowledge is an important goal for the work on Topic 1 (see T. Parts 1990).

The numerical modeling of ion-molecule reactions is another method used to study the behavior of ions in the atmosphere. At the Laboratory, Aare Luts introduced a new mathematical method that improved several times the number of constituents and reactions to be treated in one model.

## Research on Physics and Chemistry of the "Natural" Ions in the Atmosphere

Pollution-free areas; i.e., atmospheric regions in which no significant anthropogenic admixtures are found, are very rare on the Earth. In Europe, there are certainly none. The main pollution sources in Estonia are probably the oilshale-fired powerstations located in the northeast. With the predominance of western winds, Tahkuse is a good compromise for a background site. Tahkuse is situated 27 km northeast of the small town of Pärnu at a bay in the Gulf of Riga. Also, Tahkuse is about 180 km due east of the Baltic Sea, 100 km west/northwest of Tartu, and 200 km southwest of the northeast corner of Estonia where the powerstations are located. Two scientists live in an isolated farmhouse on the banks of the Pärnu River, and use instruments located in and around a large barn nearby. The environment is flat open country with some tree groups or small woods, grassland and agricultural land, and little automobile traffic. Background and scientific reasons for selecting the Laboratory and its instrumentation has been presented in five publications in the Russian language, quoted by Hõrrak et al. 1990.

The objective of the measurements is to record continuously the mobility spectra of fast and slow ions and the important atmospheric physical parameters that may influence the ion population. Main goals are to receive data to establish a reliable statistical model of the atmospheric ion spectrum, learn the factors of the spectrum, examine the role of ions in gas-to-particle conversion in the real atmosphere, and investigate the effect of air impurities on atmospheric electricity.

The central instrumentation consists of one 10-channel spectrometer and one 6-channel spectrometer which together cover the mobility ranges from $3.2 \times 10^{-8}$ to $3.2 \times 10^{-4}$ $m^2 V^{-1} s^{-1}$. The atmospheric electric field is recorded, and sferics receivers determine the existence of thunderstorms in distances to about either 10 or 30 km from the Laboratory. Air and soil

temperatures, relative humidity, atmospheric pressure, visibility, wind direction and speed, and total radiation are all continuously measured and recorded. An emergency electricity generator protects against power blackouts. Computer programs control all voltage supply features, the determination of measuring ranges, and all other instrument-setting procedures, including regular check-ups and zero-point determinations. Also, computer programs control the data processing and control of recordings. The recording unit is 1 hour, divided into twelve 5-minute cycles, subdivided into five 1-minute phases. All data are digitally stored, together with the accurate time when they were taken (or for which they were averaged) on common audio magnetic tapes. One C-90 tape contains all data of a month of uninterrupted measurements. The equipment is installed in a walk-in, thermally insulated, and air-controlled chamber about the size of a small portable building that could be transported like a container if necessary.

The design of the highly sophisticated ion spectrometers would deserve and require a special discussion in a separate report. For a reader somewhat familiar with ion measurements, I will mention that the air going through the measuring capacitors has a cylindrical mantle of deionized air around it.

The instruments are described in detail by Hõrrak, et al. (1990), and the software by Tammet (1990)--both in English. Continuous measurements with this equipment were started in July 1988.

Some individual results: using a classification of ions into three classes (cluster, aerosol, and condensed ions, according to the nature of each), Tammet et al. (1988b) suggested that neither cluster ions nor aerosol ions could be expected--near the Earth's surface--in significant numbers in the mobility range, $0.2 - 0.5 \times 10^{-4}$ $m^2 V^{-1} sec^{-1}$, while cluster ions, if they exist, could lie within that range. The new result is that there is indeed a light maximum in number density between these two limits. This result was reported at the U.S.S.R. National Atmospheric Electricity Conference in Naltshik in late 1990. Also features of the fast ion spectrum, as reported in Tammet et al. (1988b), were experimentally confirmed later. The average mobility spectrum of slow ions proves to be close to the theoretical spectrum, which is calculated on the basis of the average aerosol size spectrum. A small charge asymmetry was observed: in conditions of equal polar conductivities, the particles with diameters 15-60 nm have an approximately 20 percent higher probability to carry a negative charge than positive.

## Research on Aerosol Electricity and Atmospheric Aerosol

The Electric Aerosol Spectrometer (EAS), a sophisticated, comprehensive, and computerized instrumentation, is housed in the Laboratory building at 4 Narva Street in Tartu. The principle is to measure the atmospheric aerosol by electrically charging the aerosol particles, then determining their mobility spectra. The computer processes measuring signals that are simultaneously produced in 26 channels and processed online; it also controls the apparatus parameters. The data are stored on tape. The size range of the aerosol particles monitored is from 10 nm to 10 $\mu$m. Basically, the EAS is transportable (40x49x90 cm, 55 kg). The ability to measure the dynamics of aerosol formation is an important advantage of the EAS compared to the well-known TSI 3030 Aerosol Analyzer produced in the U.S.

At the Laboratory, the EAS is used for basic research on aerosols; e.g., formation and decay processes, including gas-to-particle conversion. Some regularities of aerosol formation on the atmosphere were first described by Mirme, Kikas, and Tamm (1990), on the basis of measurements with the EAS. Another result of these measurements is a new model for the distribution of atmospheric aerosol by Tammet (1988), providing a practical tool for investigations on atmospheric aerosol. Other applications include filter efficiencies, industrial hygiene, environmental monitoring, and investigating quickly changing aerosols.

## General Evaluation

The Laboratory has been productive in many ways. Tammet coined the correct denominations for ion counters--integral, differential of the first order and differential of the second order. Many types of ion counters were devised, theoretically and practically tested and developed, including a small hand-held one. Together with L.H. Ruhnke, Naval Research Laboratory, Washington, D.C., Tammet and Arnold conducted an experiment with a result that could be called revolutionary. They measured the "Maxwellian Current" (i.e., the sum of the densities of the air-earth conduction current plus displacement current) at two places separated by a large distance--in Estonia and Maryland. Surprisingly, they found that there are parallel variations at both places happening in the same minute or a couple of minutes (Ruhnke, Tammet, and Arnold 1983). This discovery led to the concept of the Global Atmospheric Electricity Measurement program (GAEM, see Reiter 1990).

**A Side Remark.** In the shadowy domain of the sometimes alleged influences of natural ions on human, animal, and plant health, well-being or behavior, no other country has spent so much effort as the U.S.S.R. The Laboratory at Tartu was deeply involved. They were unable to find a proven influence of natural atmospheric ions on either man, animal, or plant.

**An Illustrative Remark.** In 1983, researchers at the Laboratory published results of year-long measurements performed to determine the average spectrum of fast and slow ions in an uninhabited room to provide a baseline for special investigations. A reader may ask himself why nobody had done such work before; the need seemed so obvious (Salm and Reinart 1983, the resulting diagram republished in Weast 1986). The result of this determination raises many questions. Contrary to what one might expect, there is only one, very sharp and high peak in the range of the slow ions (aside from the expected relatively small but sharp peak for the fast ions). The peak is at a mobility which is three orders of magnitude slower than that of the fast ions. This seems to indicate that aerosol particles with radii somewhat smaller than a micrometer play a dominant role. Other questions are to which degree is this result dependent on locality? If dominant particles exist in such a narrow band of mobility, can we derive information on their chemical nature? These questions are but a small selection, and the Laboratory is finding answers. For example, recent results by Salm (1988) demonstrate the dependence of the spectrum of slow ions on the size spectrum of the aerosol. Salm's theoretical model agrees well with the experimental results obtained either by the EAS or at Tahkuse.

## List of References


Brokenshire, J., and N. Pay. Oct 1989. Ion mobility spectrometry: a promising technology for environmental measurement. International Laboratory: 38-41.

De Puy, C.H. and V.M. Bierbaum. Formation of anions in the gas phase. In *Structure/reactivity and thermochemistry of ions*, 1987, edited by P. Ausloss and SH.GF. Lias. D. Reidel, 279-303, Dordrecht.

Hõrrak, U., F. Miller, A. Mirme, J. Salm, H. Tammet. 1990. Air ion observatory at Tahkuse: instrumentation. In *Studies on aerosols and high frequency discharges*, Tartu Ülikooli Toimetised Acta et Communicationes Universitas Tartuensis, Tartu, Estonia, no. 880, 33-43.

Huertas, M.L., and J. Fontan. 1983. On the nature of tropospheric negative ions and on the influence of various polluting gases on the nature of tropospheric positive and negative ions. In *Proceedings in atmospheric electricity*, edited by L.H. Ruhnke and J. Latham, 30-32. Hampton, Virginia: Deepak Publishing.

Mirme, A., U. Kikas, and E. Tamm. 1988. Time-size structure of atmospheric aerosol. In *Lecture notes in physics* vol. 309: Paul H. Wagner and Gabor Vali (editors) Atmospheric aerosol and nucleation. Heidelberg, Springer Verlag, 52-55.

Parts, T. 1990. On the nature of negative small ions of an aging time of one second. In *Studies on aerosols and high frequency discharges*, Tartu Ülikooli Toimetised, Acta et Communicationes Universitas Tartuensis, Tartu, Estonia, no. 880, 52-61. (For positive ions see Parts, T., in the same publication series, no. 824, 1988, 69-77, in Russian.)

Reiter, R. 1990. International workshop on global Atmospheric electric measurements, *ESNIB* 90-05: 8-10.

Ruhnke, L.H., H.F. Tammet, and M. Arold. 1983. Atmospheric electric currents at widely spaced stations. In *Proceedings in atmospheric electricity*, edited by L.H. Runke and J. Latham, 76-68. Hampton, Virginia: Deepak Publishing.

Salm, J. 1988. The average mobility spectrum of large ions of the troposphere. *Research Letters on Atmospheric Electricity* (Japan), vol. 8: 21-24.

Salm, J. and M. Reinart. 1983. Measurement of the mobility spectrum of air ions over a wide range (in Russian). In *Electricheskiye Yavleniya v Gazovykh i Aerosolnykh Sredakh:* Acta et Commentationes Universitatis Tartuensis, Tartu, Estonia, no. 648, 41-45.

Tammet, Hannes. 1970. The aspiration method for the determination of atmospheric-ion spectra (translated from the Russian), by the Israel Program for Scientific Translations; National Technical Information Service, Springfield, Virginia, No. TT 68/50499.

Tammet, Hannes. 1988. Models of size spectrum of tropospheric aerosol. In *Lecture notes in physics*, vol. 309: Paul E. Wagner and Gabor Valie (editors) Atmospheric aerosol and nucleation, Heidelberg, Springer Verlag, 75-78.

Tammet, Hannes, J. Salm, and H. Iher. 1988a. Observation of condensation on small air ions in the atmosphere. In *Lecture notes in physics*, vol. 309: Paul E. Wagner and Gabor Vali (editors) Atmospheric aerosols and nucleation, Heidelberg, Springer Verlag, 239-240.

Tammet, H., J. Salm, A. Luts, and H. Iher. 1988b. Mobility spectra of air ions. In *Proceedings of the 8th international conference on atmospheric electricity*, held at the Institute of High Voltage Research, Uppsala University, 147-151.

Tammet, Hannes. 1990. Air-ion observatory at Tahkuse: Software. In *Studies on aerosols and high frequency discharges*, Tartu Ülikooli Toimetised Acta et Communicationes Universitas Tartuensis, Tartu, Estonia, no. 880, 44-51.

Weast, Robert C. 1986/1987. Atmospheric Electricity. In *Handbook of Chemistry and Physics*, CRC Press, Inc., Boca Raton, Florida, 67th edition, F149-F151. (Also printed in following editions on different pages.)


For further information, contact:


Professor Hannes Tammet
Chief Researcher
Air Electricity Laboratory
Tartu University
18 Ülikooli Street
Tartu 202400, Estonia, U.S.S.R.
Telephone: +7 (01434) 53-383; 53-450
FAX: +7 (01434) 35-440
Telex:(871) 173243 TAUN SU

Laboratory street address:

4 Narva Street
Tartu 202400, Estonia
Telephone, FAX, Telex: see above

Home address of Dr. Tammet:

56-6 Ravila Str.
Tartu 202400, Estonia, U.S.S.R.
(no telephone)

Telephone in Tammet's apartment in Tallinn:
+7 (0142) 536-002

# COMPUTER SCIENCE

## Closing a Gap Between Parallel Computing and Physical Sciences

*by Miroslaw Malek, the Liaison Scientist for Computer Science and Computer Engineering in the Office of Naval Research European Office. He is on leave from the University of Texas at Austin, where he holds the Bettie Margaret Smith Professorship in Engineering in the Department of Electrical and Computer Engineering.*

### Introduction

A focus of this report is on the highlights of the Workshop on Parallel Computing for Physical Sciences that I co-organized with Dr. Bob Ryan of Office of Naval Research European Office (ONREUR) and Professor William Jalby of University of Rennes in France. The workshop took place at Rocquencourt, near Paris, on December 3-5, 1990, and was sponsored by the Office of Naval Research (ONR), the Institut National de Recherche en Informatique et en Automatique (INRIA), and the European Office of Aerospace Research and Development (EOARD).

The workshop brought together active researchers in computer architecture and scientific applications. A stage was set for applications experts to learn about parallel computer architectures and for computer architects to gain a deeper understanding of applications. The main objective of this interaction was to stimulate a search for catalysts that would facilitate cooperation between the two groups in designing and implementing a new generation of parallel computers. As a first step, the architects described their favorite architectures and the applications group presented their requirements. Next, the workshop participants were divided into two subgroups to analyze two specific applications: (1) computational fluid dynamics and (2) sparse matrix computations. The subgroups addressed some key questions regarding the interface between parallel computing (emphasizing architecture) and the approaches to solve these two typical physical science problems. The findings were presented on the last day of the workshop.

From the outset, it became clear that computer architects and applications people (we will call them users) need some common language to communicate and understand the application requirements and to produce innovative multi-purpose architectures. Since the special-purpose computers are generally still too expensive, it seems that the most feasible way to proceed is to create a taxonomy for the applications so that a small variety of multipurpose architectures can be developed to ensure efficient, cost-effective processing for a wide class of applications. The hope here is that the physical problems, when categorized, will form classes with common properties which map nicely onto these architectures. Some progress with this idea; i.e., in domain-specific, multipurpose architectures, is quite evident. Examples include signal processing and database systems.

The participants agreed that a useful general methodology of developing a computer architecture, for an application or a class of applications, can be divided into the following six steps:

1. Application(s) definition (application semantics)
2. Algorithm(s) development
3. Computational characteristics specification
4. Computational model specification
5. Architectural design
6. Implementation.

These steps are typically reiterated and fine tuned, and should be followed by extensive performance evaluation, providing comprehensive feedback for systematic development of new generations of architectures.

Primary issues are in finding ways of describing applications, computational characteristics, and computational models to provide systematic guidance and to replace *ad hoc* methods of creating new parallel architectures. Does a suitable theory of concurrency exist? And even if it does, the same old problem of putting this theory into practice still prevails.

## Computational Characteristics

There was a consensus that one of the key elements in development of successful architectures is the ability to identify computational characteristics that can be understood and appreciated by both architects and users. Although it is not easy to derive a full list of high-level abstractions without a specific application in mind, some of them are quite universal. These pervasive concepts for computational characteristics include: type and size of input and output (e.g., input: grid with 10 million points; output: three-dimensional [3-D] pictures at 60 frames/sec), regularity (e.g., regular grid) with or without a fixed size (adaptive), density (or sparsity).

Once an algorithm is identified or developed, additional parameters may come into play--the algorithm's space and time complexity (polynomial or nonpolynomial) type; parallel or serial, deterministic or heuristic, direct or iterative, numeric or non-numeric. There is a need for higher level abstractions to describe algorithms and to go beyond simple paradigms such as "divide and conquer" and "algorithm hybridizations" (Malek et al. 1989) which seem to imply *a priori* a certain mapping to hardware.

The subgroups undertook the task of developing computational characteristics for two applications: (1) computational fluid dynamics (CFD) and (2) sparse matrix computations.

The CFD input comes in the form of a regular or irregular grid. (A complicated grid may take up to one month to generate.) Typical input sizes for flows around airplanes are 5-10 M grid points, 5-10 K operations/point, 50 K iterations. Also, a 500-Mword RAM is required. For direct simulation of turbulence, the sizes grow to about 27 M-grid points and 800-Mword RAM. The CFD also includes Boltzmann's equation computations, Monte Carlo/particle methods, flow characteristics equations, shape of solution domains (typical are 2D or 3D over time), and boundary conditions. Ideally, output should be in a form of real-time graphics with ability to make both qualitative and quantitative assessments. This requires huge amounts of data to be processed. Interactive, or ultimately automatic, control of convergence would be most desirable. These requirements necessitate a teraflop computer with lots of memory and sophisticated software.

Sparse matrix computation methods promise shortcuts for efficient processing of matrices that are truly large (over a 1,000 x 1,000), but which have relatively few nonzero entries. In spite of the fact that the working subgroup had members with wide experience in computations involving sparse matrices, there was no consensus on a definition. Various views of sparseness emerged during the discussion. A wide range of fill-up ratios, up to 60 percent, make a concept of sparseness rather fuzzy. There is a substantial difference between the problems for structured and unstructured sparse matrices, where structure is also undefined, but implies a rule for knowing where to find the nonzero entries. Potential advantages of sparse computations may become evident if the sparse matrices are structured. The hard problems arise in the unstructured cases. Many challenging questions need to be resolved. The main tasks in sparse computations focus on sparse algorithm design, compiler design, and comparative performance evaluation with classical methods. Users seem to know several tricks to improve performance, but the fundamental problem of computational characteristics of sparse computations remains open.

## Computational Model

A taxonomy of computational models makes life easier for both architects and users. Several computational models for parallel processing have been extensively studied in the past. The classical Flynn's taxonomy of SIMD and MIMD lived through many modifications. Two specific extensions include multiple-SIMD (MSIMD) and single program, multiple data (SPMD). Major battles are fought between proponents of shared and distributed (message-passing) systems. A compromise can be achieved by considering a shared virtual memory or a hybrid memory system.

## Distributed-Memory Model

This model, also known as a message-passing or loosely coupled system, enjoys a rather wide acceptance of computer science theoreticians who like logical elegance and extensibility. Languages such as occam can handle communication and partitioning. Input/output and workload distribution pose several problems, and no widely accepted language for applications is available. One of the major difficulties from a user's point of view is lack of continuity and a necessity of developing applications from scratch. (This issue of continuity, the ability for the user to move smoothly from current to future programming practice, held center stage for the users at the workshop.) There is no compiler that can efficiently handle a distributed-memory model. Nevertheless, there is a strong support for this model,

based on the belief that scalability and elegance will pay off. Therefore, several major European Strategic Programme for Research and Development in Information Technologies (ESPRIT) programs such as Parallel Universal Message-Passing Architectures (PUMA) are under way.

## Shared-Memory Model

Shared memory, as in a conventional uniprocessor, provides a global address space and allows easy programming in conventional languages such as Fortran, Pascal, C, Lisp, and Prolog. In short, it offers continuity. Simple SIMD-like parallelization (e.g., DO loops) can easily be achieved using state-of-the-art compilers.

## Shared Virtual Memory Model[1] (Giloi et al. 1991; Li 1986)

A physically distributed memory, which appears to a programmer as a shared memory supporting a global address space, is known as shared virtual memory (SVM). The SVM implies a sharing of data stored in local virtual memories with paging capability. Implementation is one of the hottest topics in computer architecture research today. The SVM promises continuity for users by providing a global address space and ease of implementation. This model can also be viewed as shared memory with caches and secondary storage in contrast to a pure shared-memory model that is considered to be without caches nor secondary storage.

## Hybrid Memory Model

This model combines both shared and distributed memory. An example of its implementation is on the IBM's Research Parallel Processor Prototype (RP3) (Pfister et al. 1985) where simple "fence registers" delineate a boundary between local and global space for each processor. With the order of tens of nanoseconds delay over a 64-way multistage network, a shared memory carries a relatively small penalty for the convenience of global access.

Some researchers believe that this approach is not scalable although others believe the opposite is true (Lipovski and Malek 1987; Cheriton et al. 1991). The state-of-the-art techniques and technology may support several thousand processor systems. With continued fast-paced progress in technology and some advances in architecture, further extensibility is assured. Optical, free-space interconnection networks may allow for a quantum leap in this area.

[1]Some researchers call it Virtual Shared Memory (Kennedy and Zima 1989).

An alternative to this taxonomy was presented by Professor Hey who introduced a parallel random access machine (PRAM) model, originally suggested by Professor Valiant from Harvard (Valiant 1990). With the PRAM model, Valiant proved universality of parallel computations similarly to the Turing result for uniprocessor machine. This idealized model allows for each of the processors to write and read into other processor memories in one machine cycle, ignoring communication overheads. Three types of PRAM models are proposed based on exclusivity of concurrent reads and writes.

1. Seclusive PRAM (SPRAM) - concurrent reads or writes to a given memory location by more than one processor are not allowed
2. Exclusive PRAM (EPRAM) - more than one processor may access the same memory module, but only one processor may access a single memory location at a time
3. Concurrent PRAM (CPRAM) - more than one processor is allowed to access the same store location simultaneously.

Valiant's models are conceptually important and push the previously discussed taxonomy even further. A grand challenge will be to validate them in practice. How important is combining (an access to a single memory location by multiple processors simultaneously) for compute-intensive problems is still an open question.

A "massively parallel" model (Giloi 1989), suggested by Professor Giloi, assumes the ability to create an unlimited number of virtual processors, one for each primitive operation or entity such as a neuron or a molecule. This model has enormous potential and should be actively pursued. The model offers a higher level of abstraction than some of the memory access models that imply a pre-emptive binding of processes or data to memories.

## Special Features and a Wish List

The aim of a discussion on this topic was to identify some "catalysts" that would accelerate understanding between architects and users. One of the primary concerns is the ability to load a given application easily and efficiently to maximize inherent data parallelism. Static and dynamic load balancers and effectively "MIMD-izers" with a standard front end would allow users to create and port their applications regardless of underlying architectures. The research in this area should intensify as the "parallelizing supercompiler" would lead to a widespread use of parallel computers. Users main concern is continuity; i.e., ability to maximize a reuse of a code developed for Cray-like machines. Users are willing to undertake some effort to "parallelize"

their applications because they do not expect the "dusty deck" problem to be solved in the near future. They would appreciate automation or interactive guidance in preprocessing, parallelization, solution refinement, and analysis. Despite a pessimistic view of some users and architects on automatic restructuring; i.e., taking a "dusty deck" and parallelizing it automatically, progress is being made. In addition, several endeavors are underway to develop interactive (semiautomatic) parallelizers. These efforts are vital for ensuring a wide acceptance and proliferation of parallel computing. Here are some additional items on a wish list. Many are well beyond a wish; they are a necessity.

**Operating Systems.** UNIX-like, fast, and intelligent, supporting both message passing and shared memory. Mach, Chorus, and Peace (Giloi 1989) seem to be a good start in this direction. Distributed workstation environments with parallel accelerator service.

**Tools.** Simulator, performance debugger (with visualization) multimedia, multidimensional, real-time visualization with qualitative and quantitative assessment, extensive libraries, and utilities.

**Languages.** Ideally, a new language is needed that assures continuity and easily captures parallelism from computational characteristics (some users switch to Mathematica). In reality, users want parallel machines that support a standard Fortran or Fortran 90. Parallel Lisp, C, and C++ are also needed.

**User Interface.** Standards with open system environment.

Key Tradeoffs

- GFLOPS and TFLOPS (architects) versus elapsed time, continuity, and convenience (users)
- Efficiency of implementation versus portability and the use of standard application packages remains to be an open question
- Shared virtual memory system versus distributed message-passing system remains an open problem.

Trends and Key Issues

- Ever-growing degrees of parallelism
- Increasingly lower cost per MFLOP
- Shared virtual memory models
- Interactive graphics interface
- Push towards portability
- Better compilers for superscalar processors
- Semiautomatic and automatic parallelization
- Progress in parallelizing compilers
- New programming models
- Heterogeneous architectures
- Improved pre- and postprocessing efficiency
- Parallel software engineering
- Instrumentation and comparative analysis
- Experimentation.

## Final Comment

Discourage computer architects from designing parallel machines and software in a vacuum. There are real people out there that need to solve real-world problems, not just academic examples.

Although it is an old plea, I feel that this time we may succeed. Parallel computers are becoming commonplace and the users are better educated and more sophisticated. They are beginning to understand what they really want and how to express their requirements in "computerese" (a language of computer people, full of acronyms and gobbledygook expressions). Eventually, both groups will have to converge and agree on an application semantics language. By launching a new research initiative on domain-specific massive parallelism for computational science, ONR is pioneering a concerted effort in this direction. One of the primary objectives is to narrow a gap between computer architects and scientific problem solvers.

## Acknowledgement

I would like to acknowledge contributions to this article by Professors Giloi and Liddell, Drs. Leca and Ryan, and other workshop participants.

## References

Cheriton, D.R., H.A. Goosen, and P. Boyle. February 1991. Paradigm: a highly scalable shared memory multicomputer architecture. *In Computer*, vol. 24, 2.

Giloi, W.K. June 1989. Genesis-the architecture and its rationale, ESPRIT Project P2702, *Technical Annex*.

Giloi, W.K., C. Hastedt, and F. Schoen. 1991. Capability-based, a distributed implementation of shared virtual memory with strong and weak coherence. In *Proceedings of the second European distributed memory computing conference*, Munich.

Kennedy, K. and H.P. Zima. 1989. Virtual shared memory for distributed-memory machines. In *Proceedings of the 4th hypercube conference*.

Li, K. 1986. *Shared virtual memory on loosely coupled multiprocessors*, Ph.D. thesis, Yale University.

Lipovski, J., and M. Malek. 1987. Parallel computing: theory and comparisons, Wiley, New York.

Malek, M., M. Guruswamy, M. Pandya, and H. Owens. January 1989. *A hybrid algorithm technique*. Technical Report. Department of Electrical and Computer Engineering, University of Texas at Austin.

Pfister, G.F., W.C. Brantley, D.A. Gorge, S.L. Harvey, W.J. Kleinfelder, K.P. McAuliffe, R.A. Melton, V.A. Norton, and J. Weiss. 1985. The IBM research parallel processor prototype (RP3): Introduction and architecture. In *Proceedings of 1985 the international conference on parallel processing*, 764-771. Chicago.

Valiant, L. G. 1990. Bridging model for parallel computation, *Communications of the ACM* 33, No.8.

# COLING-90 Conference

*by John Bear and Jerry R. Hobbs, Artificial Intelligence Center, SRI International, Menlo Park, California.*

## Introduction

Any conference such as COLING-90 (Computational Linguistics) is to some extent a reflection not only of the progress and ongoing work in the field, but also of the tastes and views of the conference organizers. Moreover, any individual's view of a large conference is necessarily biased by his or her interests. Hence, any attempt to make accurate and objective generalizations about the state of affairs in computational linguistics based on the papers presented at COLING-90 will not be entirely satisfactory. Given this caveat, we will present some of our own views about what trends and progress were evident at the most recent COLING conference in Helsinki.

Judging from the panels and papers in the conference, there is a growing concern about large volumes of data. Researchers have been trying to glean information from large online dictionaries, both monolingual and multilingual, for many years. Now there is a growing interest in using large bodies of text both as training data for various kinds of text processing systems, and as a way of testing the systems' effectiveness, or simply demonstrating a system's capabilities. A good example of this kind of work is H. Inagaki, S. Miyahara, T. Nakagawa, and F. Obashi's paper "Sentence Disambiguation by Document-Oriented Preference Sets."

One of the panels, entitled "Unfinished Language," had as its focus the problem of dealing with words that are not in the lexicon of whatever type of system is being developed. To put it another way, it is impossible to build up a lexicon that contains all the words the system might need. Establishing a panel is evidence of shifting attention away from trivially small domains of made-up examples on which to demonstrate parsers and generators, toward solving some of the problems that are inherent in more naturally occurring texts and discourses.

Another bit of evidence for this trend was apparent in the report of the workshop on textual and lexical resources. There are initiatives for collecting different kinds of machine-readable texts and putting them into a form that makes them useful for researchers who want to work with large amounts of naturally occurring data.

There were several papers dealing with techniques for parsing and understanding sentences whose main distinguishing characteristics were not that they had any of the traits theoretical linguists discuss, but rather that they were long, naturally occurring sentences. An example of this is W.C. Li, T. Pei, B.H. Lee, and C.F. Chiou's paper "Parsing Long English Sentences with Pattern Rules."

## Papers Presented

As further evidence of this trend, we can cite the papers that addressed methods of using large amounts of textual data to train a parser in the parallel processing model, such as K. Faisal and S. Kwasny's paper "A Hybrid Deterministic Parser." Or one can produce co-occurrence probabilities (if one prefers to think in terms of statistics) as in N. Calzolari and R. Bindi's paper "Acquisition of Lexical Information from a Large Textual Italian Corpus." These papers are, in fact, good examples of one type of work that characterized COLING-90. Researchers take two or three different techniques, and combine them to form a system that has some of the good points of each.

Another trend is including work on phonology and speech recognition in mainstream computational linguistics. There were at least three papers on unification phonology at the conference, such as J. Coleman's paper "Unification Phonology," and more on other aspects of phonology and speech recognition. Overall, phonology seemed to be better represented than in previous years.

Unification seems to be a very widely used tool in a myriad of domains despite its proven complexity. However, it is still being developed. There were papers presented that describe new ways of doing unification, such as J. Dörre and A. Eisele's paper "Feature Logic with Disjunctive Unification" and T. Yampol and L. Karttunen's paper "PATR for Categorical Unification Grammar."

The tree-adjoining grammar (TAG) formalism seems to be slowly gaining popularity. A paper by S. Shieber and Y. Schabes, entitled "Synchronous Tree-Adjoining Grammars," proposed a solution to one of the problems of tree-adjoining grammars--how to do semantics in a reasonable way. This paper could be a harbinger of a growing acceptance of TAGs. The paper solves a problem that has been a major obstacle to the use of TAGs. Namely, there have been no good ways of expressing systematic relationships between the syntax and the semantics. This paper could make people rethink their positions on the usefulness of TAGs.

Although there is reason to believe TAGs may soon become more widely used, they were not the dominant way of doing syntax at this conference. The dominant grammar formalisms still seem to be LFG, GPSG or HPSG, and PATR. Also well represented at COLING was GB, but it should perhaps not be described as a formalism.

An international conference on computational linguistics like COLING-90 is perhaps the best place to assess the state of the art in one area of computational linguistics--namely, machine translation. There has been work on a wide range of language pairs, as indicated below.

There seemed to be three dominant themes in the machine translation papers at this conference. The first was reversibility--the idea that the same grammar should be usable for both interpretation and generation, allowing a single formalism for the entire translation process.

G. Van Noord's paper "Reversible Unification-Based MT" (English-Spanish) first showed how transfer can be accomplished by unification, and then derived several constraints a grammar must satisfy if it is to be reversible in any practical sense.

Among the best of the work reported was M. Dymetman, P. Isabelle, and F. Perrault's paper "A Symmetrical Approach to Parsing and Generation." They introduced the notion of guides, (generally strings in parsing and logical forms in generation) that are consumed in the parsing or generation processes and constrain their complexity. They showed how, from a single grammar, this idea can be used to generate different grammars for parsing and generation--grammars that lend themselves to efficient processing.

The second dominant theme was the problem of translating examples where the modes of expression in the two languages are very different. The approaches taken to this problem can be classified as either transfer approaches or as interlingual approaches.

A. Abeillé, Y. Schabes, and A. Joshi's paper "Using Lexicalized TAGs for Translation" (English-French) gave a very clear and elegant exposition of the transfer approach as it would be applied in the context of TAGs. At first blush, their rules look like familiar tree fragment transfer rules. Because of the power of TAGs, these rules not only constitute the transfer relations among syntactic structures in the two languages, they also specify the two grammars themselves. They show how one would approach several syntactic mismatch problems in their framework, including cases of differing realizations of predicate-argument relations and the head-switching problem (as exemplified in the translation from "The baby just fell" to "Le bébé vient de tomber"). The authors thus showed how a wide range of mismatch problems can be handled without going to an interlingual level of analysis.

L. Carlson and M. Vikuna's paper "Independent Transfer Using Graph Unification" (English-Finnish) also showed how unification can be used for transfer.

D. Santos' paper "Lexical Gaps and Idioms in Machine Translation" (English-Portuguese) was concerned with the lexical mismatch problem (particularly, the problem of a single word in the source language mapping into a phrase in the target language).

Among the most interesting papers using the transfer approach was S. Sato and M. Nagao's "Memory-Based Translation" (English-Japanese). In any practical machine translation system, there will always be input sentences that are not covered by the existing rules. Sato and Nagao defined precisely how one can examine already existing translations to determine how to translate the problematic input analogously. They also provided a way to score alternative translations using various structural factors.

Interlingual approaches tended to show how some of the mismatch problems can be handled by analyzing the source text to a deeper level of representation. For example, G. Gardent and A. Plainfossé's paper "Generating from Deep Structure" (English-French) addressed the problem arising when two languages realize the predicate-argument structure in surface forms in different ways; e.g., "The mouse misses the cat" into "Le chat manque à la souris." Their solution is to use as their interlingua a deep structure that encodes predicate-argument relations but does not record linear ordering.

J. Bateman's excellent paper "Translation and Grammatical Metaphor" (English-German) addressed the problem of translating from nominalizations to verbs, from verbs to subordinate conjunctions, from possessives to reflexives (as from "Mary cut her finger" to "Mary schnitt sich in den Finger"). Working in systemic grammar, his approach was to define multiple mappings from an interlingual representation into surface form and to specify the choices among the mappings that a generation program must make and an interpretation program must recognize.

Probably to be classified as an interlingual approach was M. Salkoff's paper "Translation of Support Verb Constructions" (French-English). He was also concerned with the lexical mismatch problem, in particular with constructions involving support verbs. His approach was to apply transformations within each language with structures annotated as to whether the construction directly translates.

C. Zelinsky-Wibbelt's paper "Representing Spatial Configurations for Generation" (German-English) also addresses the lexical mismatch problem, in particular, the very difficult problem of translating prepositions. Her proposal is interlingual in nature. The sentences are

given a deep representation based on Leonard Talmy's theories about how people represent spatial relations.

With some language pairs, one must supply definite and indefinite articles in the target language that are absent in the source language. B. Gawraska-Werngren addressed this problem in her paper "Translation Great Problem": On the Problem of Inserting Articles When Translating from Russian into Swedish." Her solution is first to determine whether the NP is heavily modified. If so, it is assumed to be determinative and hence definite. Then she checks whether resolution of the NP is possible by looking for implicative relations between lexical items as evidence for coreference. Where these are found, the NP is assumed to be definite.

A third, though less dominant, theme was using convenient user interfaces for disambiguation in the pre-editing stage of translation, using constraint propagation to minimize the number of interactions with the user. R. Brown and S. Nirenburg's paper "Human-Computer Interaction for Disambiguation" described an interface for lexical disambiguation. The user chooses from among a set of listed senses of an ambiguous word, and selectional constraints are used in constraint propagation to resolve other ambiguous items.

H. Maruyama's paper "An Interactive Japanese Parser for MT" (Japanese-English) described a particularly elegant interface for disambiguating attachment ambiguities. The user can select with a mouse ambiguously attached modifiers in any order, the potential attachment points are highlighted, and the user can select the correct one with a mouse. The noncrossover constraint is then used in constraint propagation to disambiguate other ambiguous items.

C. Boitet's paper "Towards Personal MT" (French-English) described an implementation of machine-aided translation on a personal computer. The system conducts disambiguation in the post-editing phase, dealing with such things as ambiguities of bracketing, lexical clarification, and expanding lexical ellipses.

In a more programmatic paper, entitled "Machine Translation Without a Source Text," H. Somers, J. Tsujii, and D. Jones proposed a system that will aid a user who knows one language to write the article originally in a language he does not know. In a way, this is machine translation without a source text. Ultimately, good translation requires mapping the source language into the speaker's plan and then mapping that out to the target language. The authors' proposal is simply to dispense with the first half of that process and work directly from the speaker's plan, as elicited by the system.

## Summary Comments

From systems for doing machine translation to unification phonology, the papers at COLING-90 span a very large range. The papers and topics we have discussed here are only examples of what we see as trends. We have tried to be objective, accurate, and succinct in our assessment. Perhaps COLING-92 will provide an indication of the extent to which we have succeeded.

To obtain the conference proceedings (3 volumes) for $190 ($95 for ACL members), contact

Dr. Donald Walker (ACL)
Bellcore, MRE 2A379
445 South Street, Box 1910
Morristown, New Jersey 07960-1910

**Appendix**

## COLING 90 Presenters

1. H. Inagaki, S. Miyahara, T.Nakagawa: NTT Human Interface Laboratories, Kanagawa, Japan
2. F. Obashi: NTT Intelligent Technology Co., Yokohama, Japan
3. W.C. Li, T. Pei, B.H. Lee, and C.F. Chiou: Industrial Technology Research Institute, Chutung, Hsinchu, Taiwan
4. K. Faisal: Information and Computer Science Department, King Fahd University of Petroleum and Minerals, Dahran, Saudi Arabia
5. S. Kwasny: Deptartment of Computer Science, Washington University, St. Loois, MO
6. N. Calzolari and R. Bindi: Department of Linguistics, University of Pisa, Pisa, Italy
7. J. Coleman: Department of Language and Linguistic Science, University of York, York, England
8. J. Dörre and A. Eisele: Institüte fur Maschinelle Sprachverarbeitung, Universität Stuttgart, Stuttgart, Germany
9. T. Yampol: Stanford University, Stanford, CA
10. L. Karttunen: Xerox PARC, Palo Alto, CA
11. S. Shieber: Computer Science Department, Harvard University, Cambridge, MA
12. Y. Schabes: Department of Computer & Information Science, University of Pennsylvania, Philadelphia, PA
13. G. Van Noord: OTS RUU Trans 10, Utrecht, Netherlands
14. M. Dymetman, P. Isabelle, and F. Perrault: CCRIT, Communications Canada, Laval, Quebec
15. A. Abeillé: LADL, University of Paris 7-Jussieu, Paris, France
16. Y. Schabes and A. Joshi: Department of Computer & Information Science, University of Pennsylvania, Philadelphia, PA
17. L. Carlson and M. Vikuna: Department of General Linguistics, University of Helsinki, Helsinki, Finland
18. D. Santos: IBM-INESC Scientific Group, Lisboa, Portugal
19. S. Sato and M. Nagao: Department of Electrical Engineering, Kyoto University, Kyoto, Japan
20. G. Gardent: Université Blaise Pascal, Clermont Ferrand, France
21. A. Plainfossé: Laboratoires des Marcoussis, Marcoussis, France
22. J. Bateman: USC/ISI, Marina del Rey, CA
23. M. Salkoff: LADL, University of Paris 7-Jussieu, Paris, France
24. C. Zelinsky-Wibbelt: IAI-EUROTRA-D, Saarbruecken, Germany
25. Gawranska-Werngren: Department Linguistics, Lund University, Lund, Sweden
26. R. Brown and S. Nirenburg: Center for Machine Translation, Carnegie-Mellon University, Pittsburg, PA
27. H. Maruyama: IBM Research, Tokyo Research Laboratory, Tokyo, Japan
28. C. Boitet: GETA, IMAG Institute, Grenoble Cedex, France
29. H. Somers, J. Tsujii, and D. Jones: Centre for Computational Linguistics, UMIST, Manchester, England

# MATERIALS

## Critical Research Directions in Metal-Matrix Composites

*by M.G. Bader, Department of Materials Science & Engineering University of Surrey, Guildford, U.K., and Michael J. Koczak, Office of Naval Research European Office.*

### Introduction

Metal-matrix composites (MMC) have emerged as a class of materials for advanced structural and electronic applications. These alternatives to conventional materials provide the necessary specific mechanical properties for elevated and ambient temperature applications. The structural potentials for these materials have been exploited but the result rarely has been cost effective. Aluminum matrix composites have been developed to a commercial basis, and several processing routes are available; i.e., squeeze casting, Osprey forming, powder processing, and plasma deposition.

Aluminum matrix composite alloys have been used extensively in aerospace structural applications at ambient temperature because of their high specific strength; i.e., a high strength-to-weight ratio. There has been a concerted research effort to develop aluminum alloys for applications at above-ambient temperatures. The development of these alloys would make it economically viable to replace existing Ti alloys and stainless steel in certain aerospace engine components. In addition to synthetic fibre/particulate systems, *in-situ* metal-matrix composites using carbide/nitride reactions involving liquid metal and gases is a novel concept for developing reinforced alloys with high strength and modulus as well as good elevated temperature stability. Metal-matrix composites may be utilized to develop high-volume fraction, thermally stable, wear-resistant alloys as well as alloy composites with tailored or graded physical properties; i.e., acoustic, wear, coefficient linear expansion and thermal conductivities.

### Workshop Goals

The Office of Naval Research sponsored a workshop in Stuttgart, the Federal Republic of Germany, (FRG) September 28 and 29, 1990. The goals of the workshop were

- Consensus on the present state of research in metal-matrix composites
- Relevance of this state of research to the needs of industry in Europe and the U.S.
- Priorities for future research.

The meeting lasted 2 1/2 days and followed the fourth annual European Conference on Composite Materials (ECCM-4) in Stuttgart, FRG.

The delegates participated by invitation (see Table 1).

**Table 1. Workshop Participants**

| Participant | Affiliation | Country |
|---|---|---|
| Mr. M.G. Bader | University of Surrey | G.B. |
| Dr. G. Chadwick | Hi-Tech Metals | G.B. |
| Dr. D. Divecha | Naval Surface Warfare Center | U.S. |
| Dr. P. Gruber | Sigma AG (Representing BP) | FRG/G.B. |
| Dr. K.U. Kainer | Technical University of Clausthal | FRG |
| Dipl. Ing H. Kaufmann | Aluminum Ranshofen | A |
| Dr. M.J. Koczak | Office of Naval Research | U.S. |
| Dr. H. Lilholt | RISO National Laboratory | DK |
| Dr. S. Mielke | Kolbenschmidt AG | FRG |
| Dr. Y. de Pettitcorps (Written submission) | Lab. de Chemie du Solide du CNRS Bordeaux | F |
| Dr. K. Schulte | DLR Koln | FRG |
| Dr. M. Suery | Polytechnique de Grenoble | F |
| Dr. R. Warren Chalmers | University, Göteborg | S |
| Dr. M.C. Witt (Written submission) | BP, Sunbury | G.B. |

**Country Key:**

| | | | |
|---|---|---|---|
| A - | Austria | F - | France |
| DK - | Denmark | G.B. - | Great Britain |
| FRG - | Federal Republic of Germany | S - | Sweden |
| | | U.S. - | United States |

They were selected to represent industry, research laboratories, and universities from European countries known to be active in MMC and the U.S. Twelve people

attended; 6 European countries and the U.S. were represented. Two attendees contributed written submissions. This report contains an analysis of opinions of the current state of MMC research, and recommendations for future research paths. There was an overwhelming consensus that research should be process- rather than materials-driven, and that processing machinery development projects should be launched.

## Organization

The workshop was organized into two main sessions subdivided into plenary and group discussions. In the initial plenary session, the delegates were briefed on the objectives of the workshop, and each was invited to respond to questions that had been circulated before the meeting. Two discussion groups were formed, each comprising industrial and academic representation, to further consider the identified topics. Each group held two sessions. Then, at a plenary session, each group leader presented his group's conclusions. The participants discussed these conclusions and established a framework for this report. The discussions were remarkably free, frank, and wide ranging; the final conclusions were unanimous.

## Metal-Matrix Composites: Motivation

As mentioned in the Introduction, metal-matrix composites have been developed as a new class of composites for advanced structural applications. The synthetic metal-matrix composites reflect a thermodynamically unstable artificial mix of fiber and matrix, and reflect the high cost of fiber reinforcements and processing. For successful progress and application of metal-matrix composites, major fundamental scientific challenges lie in the materials processing, synthesis, kinetic understanding, thermodynamic control, reinforcement stability, and strength. By control of the melt (i.e., alloy matrix design) and interface reactions, a stable metal-matrix composite may be generated. During the past decade, specific property material requirements for advanced applications have escalated where conventional alloy systems are not suitable. Attempts to enhance the performance characteristics of monolithic metallic materials by reinforcement with a high-strength/high-stiffness second phase are therefore required. The commercial motivation directed is towards developing a cost-effective, metal-matrix composite.

By selecting the appropriate reinforcing constituents of a material (i.e., volume fraction, shape, and size), it is possible to design alloys to enhance strength and stiffness. Metal-matrix composites incorporate a wide variety of metal systems (e.g., Al, Mg, Ti, Cu, Ni alloys) using several types of reinforcing phases in the form of whiskers (SiC), monofilament (e.g., SiC, B, W), fiber (e.g., SiC, Alumina, graphite) and particulate (e.g., TiC, SiC). In application-driven environments, MMCs are gaining rapid prominence in the future automotive and aerospace industry. Higher-operating temperatures of materials and wear resistance are mandated by the increasingly stringent performance requirements by the aerospace and automotive industry. Although titanium alloys are used at the intermediate temperature ranges and result in an increase in cost and weight. Development of aluminum-based, cost-effective composites that would be usable at elevated temperatures (T > 250C) would be beneficial to design engineers in automotive and aerospace applications.

## Significant Research Contributions

The group was invited to nominate those research and development (R&D) achievements of the past 5 years that they considered to be the most significant. A short list was agreed upon and is given below. It is interesting that industrial developments were highlighted and predominated subsequent discussions.

## Significant Advances

- Development of reinforced pistons using preform infiltration technology.
- Osprey and Co-spray processes for assembling MMC ingots and products.
- Development of large-scale production capacity for commercial particulate composites by both foundry and powder routes. (Alcan/Duralcan Co., Hydro-Aluminum Co., BP, and Alcoa.) These developments were considered to provide the necessary base capacity for the first-volume production applications of MMCs.
- Significant progress had been made towards understanding interfacial reactions and developing effective fibre coatings to control these processes.
- Micromechanical modeling of discontinuous systems and creep had made useful progress.
- Work on metal-fibre reinforced systems has led to renewed interest.

## Current Research Expertise in Europe and the U.S.

Delegates were asked to assess the research expertise within their own countries and to identify areas of strength and depth. The results are presented by country in the following summaries.

**Austria.** There is an interest in both continuous- and short-fibre/particulate reinforced systems. The main driver for research is processing and understanding physical properties. Significant research effort is devoted to

- Liquid metal-infiltration processes for continuous short-fibre and particulate systems using aluminum- and magnesium-based alloys
- Machinery and process development for extrusion and pressure die-casting
- Casting research for Duralcan-type materials
- Physical properties.

**Denmark.** The emphasis is on more academic aspects of research primarily directed towards understanding structure/property relationships:

- Internal stress analysis, creep
- General theories for two-phase materials
- Microstructural effects - recrystallization
- Interfaces and coatings.

**France.** There are several active groups both in industry and universities. Overall, more resource is deployed on MMC than in other European countries. The emphasis is on developing viable industrial systems.

- High- and low-pressure preform infiltration processes
- Studies of wetting, interfaces, and coatings to support infiltration process development
- Mechanical property evaluating and modeling, developing test methods
- Studies of fibre/matrix interactions; degradation at the interface and metallurgical effects; e.g., aging
- Semisolid processing routes
- Co-spray and related technologies
- New fibre development: SiC/SiN (Sicar) (Rhone Poulenc)
- Materials systems include Ti reinforced with B and SiC-based fibers, Al and Mg alloys with C, SiC, and $Al_2O_3$.

**Federal Republic of Germany.** The predominant interest is in short-fibre and particulate systems, although there is also a significant effort directed towards continuous-fibre materials for advanced aerospace projects. Joint funding schemes encourage collaboration between industry and universities.

- Piston production using infiltration and powder technology
- Machinability, friction, and wear studies associated with automotive applications
- Powder-based fabrication routes: process and materials optimization
- Interface and coating studies
- Mechanical property studies, including creep and elevated temperature performance
- Materials of interest: Al and Mg alloys reinforced with particulate and short-fibre (SiC, $Al_2O_3$); Al and Ti reinforced with continuous fibers; metallic wire reinforcement.

**Great Britain.** Research in industry, research associations, and at universities. Significant programs directed toward both low-cost automotive and general engineering applications and to high-performance aerospace requirements.

- Mechanical testing and modeling, thermochemical modeling for process development
- Process development: high- and low-pressure preform infiltration, Co-spray and related processes, powder metallurgy, and foundry-based processes
- Fibre development: $Al_2O_3$ (ICI), SiC (BP)
- Interface characterization, matrix optimization, coating technology.

**Materials system.** Al and Mg with continuous and discontinuous reinforcement, Ti/SiC coupled with superplastic forming and diffusion bonding (SPFDB) techniques.

**Sweden/Norway.** Primary focus is on

- Processing, microstructure, and properties of Al and Mg alloys reinforced with SiC and $Al_2O_3$ (short-fibre, particulate), produced by foundry and powder routes
- Tungsten fibre (wire)-reinforced superalloys for gas turbine applications
- Hybrid composites (Ranfoss).

**United States.** Focus is on very large industrial involvement, together with several university groups and research institutions.

- Large companies are involved with the development of commodity MMC based on particulate systems (Alcan, Alcoa). Many smaller companies developing defense-driven, high-performance materials for military and aerospace
- Fibre development: (Textron, Dupont, Corning, Amoco): B, SiC, C, and ceramic
- Process development for particulate and continuous systems: foundry- and powder-based routes
- Mechanical property studies, creep, fatigue, and elevated-temperature performance
- Chemical synthesis techniques, intermetallic-based systems ($Ti_xAl_y$)
- Interfacial studies, wetting, alloy optimization
- Large-scale production (Alcan, Duralcan)
- Numerical modeling for performance and processing.

## Limitations To Progress

After lengthy discussions, several specific limitations were identified. Overall, however, the principal barriers to progress have been high cost, coupled with a lack of understanding of long-term performance, and hence, reliability. There have been relatively few applications other than demonstrator projects for military and aerospace applications. This state of affairs will only be resolved when MMCs have demonstrated their performance and reliability in extended service. By contrast, the polymer matrix systems have been extensively used for the manufacture of sports goods. This sustained the industry during a critical development period and provided a low-risk arena for their appraisal. The only significant commercial development for MMC, thus far, has been the reinforced Al-alloy piston.

**Theory.** Micromechanical models for particulate and short-fibre systems provide an inadequate basis for design. Further work is also required on the creep, fatigue, and toughness of continuous-fibre systems.

Interface stability remains the principal limitation to high-temperature performance. There is a need to develop thermodynamics and kinetics-based models to adequately predict behavior, and to use as a design tool for developing fibers, alloys, and coatings.

**Materials.** Current fibers are considered to be inadequate. There is a critical need to develop low-cost fibers; i.e., cost comparable to carbon. Chemically pure fibers; e.g., alumina, were considered desirable on the grounds of reduced reactivity with metallic matrices. Of the currently available continuous fibers, it was considered that the larger-diameter fibers were preferable. Coating/protection technology needs to be further developed. The multifilament, SiC-based fibers (e.g. Nicalon® and Tyranno) were considered to be inadequate on several counts, especially strength and stability. Of the alumina-based fibers, Saffil® and Saffimax® were considered to be the most promising. Current continuous $Al_2O_3$ fibers were too costly for their performance. A cheaper, high-performance alumina fibre was clearly needed. There was a continuing interest in metallic fibers: W-based alloys and intermetallics in both continuous and high-aspect, ratio-discontinuous forms. It was considered that a high-performance, ductile fibre would have considerable potential. Likewise, there was continued interest in the exploitation of high-aspect ratio whiskers, despite possible health hazards.

Matrix materials had not received sufficient attention. There was a tendency simply to reinforce an existing alloy, without consideration of the possible influence of the reinforcement on the matrix. There was a real need to develop integrated systems where the matrix was tailored to the reinforcement. This is especially necessary in the particulate- and preform-infiltrated systems based on foundry processing methods.

It was considered that Mg had been under-exploited as a matrix for lower-cost MMCs. Also, it had a considerable density advantage over Al, coupled with often better-elevated temperature performance and machinability.

Nanocomposites (based on metal/ceramic systems) were considered to be a suitable topic for longer-range research.

**Processing.** This is the most important area for current development. Many processes, especially for continuous fibre systems, are very slow and complex. This leads to high processing costs and to a lack of uniformity and reliability because of inadequate control. The development of sophisticated production machinery for all classes of MMCs is a pressing need and is vital if costs are to be reduced.

Further development is required in near-net shape production technologies and the development of semifinished shapes (rods, tubes, sheets) should be pursued.

There is an urgent need to develop better nondestructive evaluation (NDE) and quality assurance techniques. The availability of fast, low-cost techniques is vital for the establishment of viable, large-scale production operations. It is recognized that this is no easy task!

Another area in which further research is required is in machinability, machining, and recycling. Machining has received some attention, but MMCs are among the most difficult materials to machine (i.e. a consequence of their excellent wear resistance). The development of viable systems may require research directed to both materials and tools and methods. Recycling has received scant attention but must be addressed if large volumes of MMCs are to be produced. Contamination of the matrix with the reinforcement may (at best) reduce the value of scrap and (at worst) may render scrap contaminated with MMC unreclaimable.

The final identified processing-related area was that of secondary forming and joining. It was considered that these aspects of processing would become more dominant as the MMC technology matures.

## Future Research Needs

**General.** There was unanimous agreement that research should be process-driven rather than materials-driven. There was a great diversity of materials and fabrication routes, but little understanding of the relationships between processing and performance. There was a view from industry that the expertise in universities was not being adequately exploited. Materials were difficult to acquire. Universities were studying virtually anything obtainable, regardless of whether it was state of the art or obsolete, and often with inadequate information on its constitution and processing history. This is very inefficient, and manufacturers are urged to ensure that university facilities are utilized on meaningful investigations. There is a need for less inhibition of collaborative research caused by secrecy and proprietary considerations.

**Continuous-Fibre MMCs.** The principal driver for the development of continuous-fibre MMCs is enhanced properties at elevated temperatures. Specifically, there is a need to extend the useful operating temperature of aluminum alloys to 500°C, titanium alloys to 1000°C, and nickel-based super-alloys to >1200°C. All these materials have potential in engines and structures for advanced aerospace and military applications. Continuous-fibre, reinforced aluminum is perceived to have possible applications in the automotive field, but economic viability is questionable.

Processing routes for these materials are necessarily expensive, and will remain so. Nevertheless, a coordinated research effort directed towards optimization of fabrication routes is desirable. The other critical aspect is control of the interface and fibre/matrix reactions. Both require more attention to be directed towards matrix optimization, coordinated with tailoring of the fibre (and coating) for long-term stability at elevated service temperatures.

**Short Fibre and Particulate Systems.** Here the need is for an even greater concentration of effort on processing. The most promising materials systems have been identified and the pressing need is for efficient and reliable manufacturing routes. Since these materials are destined for lower-cost, high-volume applications, there is a greater need for process and machinery development and for process modeling to underpin quality assurance and reliability.

The matrix alloys are those based on aluminum and magnesium, and reinforcements include $Al_2O_3$ in particulate and staple-fibre form and SiC as particles and whiskers. Foundry-based techniques--preform infiltration, stir-, and squeeze-casting--are likely to become the dominant technologies, although powder metallurgy routes will probably continue to contribute to the upper end of the performance bracket. Coordinated research programs are needed in the following processing areas:

- Preform infiltration
- Ingot manufacture by stir casting
- Ingot and net-shape products by powder routes
- Machinery development for the above processes
- Secondary forming from ingot material.

In this latter category, techniques include extrusion and forging of cast or powder-consolidated stock and semiliquid-forming processes. In developing these materials, the general approach has been to produce MMCs by addition of reinforcement to standard alloys. This is understandable on grounds of availability of ingot stock and a reluctance to embark on expensive alloy development programs. There is a clear need to develop optimized-alloy formulations for use in reinforced systems. There are three principal reasons for this:

1. In foundry-based technologies, especially preform infiltration, the presence of a significant-volume fraction of reinforcement has a dramatic effect on heat transfer during processing. Cooling rates are higher with consequential morphological changes. This leads to the need for higher preheat in the metal before infiltration (casting).
2. The metal becomes contaminated by reaction with the reinforcement (and/or binder). In infiltration systems, a compositional gradient develops caused by the molten metal sweeping through the preform. A further effect is that the preform may act as a filter and retain primary phases during the first stages of solidification. These compositional variations lead to modified aging behavior (often inhibition of normal hardening processes).
3. The foundry techniques for manufacturing MMCs are often radically different from those used for conventional-casting alloys, so conventional approaches to alloy optimization may no longer be appropriate.

## Areas for Coordinated Action

Many proposals were debated. The results were classified under four headings--General, Nonaerospace/Industrial, Aerospace Applications, and Academic Research Requirements.

1. General

- **NDE** - There is an overwhelming need to develop more effective NDE procedures. This is felt by all sectors, e.g. processors and users in aerospace and general engineering industries.
- **Fibers** - A large diameter (100mm), stable-oxide fibre is needed, perhaps based on a $Al_2Ti_xO_y$ formulation. A need for a ductile (metal) fibre was also expressed. The performance of current fibers was seriously inadequate for projected high-temperature MMCs ($>1000^{\circ}C$). Equally, they are too expensive for general engineering applications.
- **Particles** - There is a need to develop improved techniques for handling small particles and whiskers in the MMC industry.
- **Nanocomposites** - Work should be encouraged on MMCs based on a very fine scale *in-situ* reinforcement.
- **Applications** - There is a need to identify and develop new application areas for the exploitation of MMC in both auto/general engineering and in aerospace/high-technology areas. It is recognized that high-volume applications are needed to establish the longer-term economic viability of MMC.

2. Nonaerospace Industrial

- **Process Development** - This needs to be addressed over the whole spectrum of potential large-scale manufacturing processes. Specific areas are developing and optimizing preform manufacture and infiltration processes; in particular, developing improved processing machinery. There is also a need for extensive R&D in powder-route processes and in postforming technologies, especially semiliquid forming.
- **Other Areas** - Machinability, recycling, and corrosion.

3. Aerospace Applications

- **High Temperature** - The principal need is to develop improved continuous-fibre reinforced materials for use at elevated temperatures in engines and high-speed vehicle structures:
  * Al alloys to $500^{\circ}C$
  * Ti alloys to $1000^{\circ}C$
  * Ni alloys to $1200^{\circ}C$.
- Coordinated research is needed to concentrate expertise and to avoid unnecessary duplication of effort. This should include fibers, coatings, alloy optimization, and interface studies, together with long-term property studies (creep, fatigue, toughness).
- **Low CTE** - Further development is required for materials, based on continuous fibers (pitch carbon?) with very low coefficients of thermal expansion (CTE) for use at temperatures of up to $1700^{\circ}C$.

4. Academic Research Requirements

While many of the topics identified above could usefully involve academic institutions, several were identified that were considered especially relevant.

- **Thermochemistry** - Development of thermodynamics and kinetics computational techniques into a useful predictive tools for MMC development. Possible areas are alloy design, thermal processing guidelines, interface reactions, and long-term metallurgical and environmental reactions.
- **Matrix Design** - Optimization of matrices for specific fibre/coatings/processing/service environment combinations.
- **Coatings**. This is probably the most critical current need. New coating and application techniques are required with specific attention to economic viability.
- **Reactions**. Coupled with the topics listed above is the urgent need for further, relevant, studies of reactions between the matrix and the reinforcement.
- **Models** - Further work is needed on developing integrated models for the behavior of MMC materials under service loads. These include creep and fatigue of continuous-fibre systems, and especially, better models for discontinuous-fibre and particulate materials.

## Specific Recommendations

Apart from the specific topics identified, there was a very strong consensus that much more collaborative research involving raw materials producers, processors, users, and academic and research institutions was needed. It was felt that much current research was inhibited by the lack of availability of well-characterized, state-of-the-art materials. There was also concern about unnecessary secrecy and protection of proprietary interests. While the need to protect national and company property rights was recognized, it was considered that the present levels of control were counterproductive and were inhibiting progress.

## Summary

Advances in fiber, whisker, and particulate chemistry and processing have led to advanced aluminum-base materials. Specifically, the addition of fiber, whiskers, or particulate SiC produces a composite material with excellent specific mechanical properties. Techniques can include squeeze and centrifugal casting, mechanical alloying, powder blending, and consolidation or spray deposition. The strength of fiber-, whisker-, and particulate-reinforced aluminum clearly depends upon the fiber and matrix properties, whisker volume fraction, aspect ratio, and orientation. In addition, the excellent fiber- or whisker-reinforcement properties must be maintained during the solidification, infiltration or consolidation, and extrusion processes to achieve the full potential of metal-matrix composites.

If fiber interactions, reduction of fiber length, or surface damage occurs, the subsequent metal-matrix composite will suffer a natural strength reduction. These factors have been examined analytically and experimentally to define structurally competitive properties of reinforced aluminum-base material systems. A balance of properties must be achieved in these reinforced alloys. Specifically, reinforcements will enhance modulus, strength, and creep resistance while reducing ductility, fracture toughness, and notched tensile properties. A compromise in the volume fraction, size, and distribution of the reinforcement phase is required to achieve a useful structural alloy.

In general, increases in the modulus and yield strength occur with a marked reduction in failure strain. The application of metal-matrix composites via solidification, infiltration, powdermetallurgy route, or combined by mechanical alloying or spray deposition can offer a high-modulus, high-temperature material. However, the process and design engineers must ensure property reliability and cost-effective processing for commercial exploitation.

# Powder-Free Processing for Advanced Ceramics

*by Michael J. Koczak, the Liaison Scientist for Materials for the Office of Naval Research European Office. Dr. Koczak is on sabbatical leave from Drexel University, Philadelphia, Pennsylvania, where he is a Professor of Materials Engineering.*

## Introduction

A workshop on Powder-Free Processing for Advanced Ceramics was orchestrated by Drs. R.J. Brook and R. Riedel of The Max Planck Institute, Stuttgart, the Federal Republic of Germany (FRG). The goal of the workshop was to establish the viability of alternative processing methods that would allow the fabrication of ceramics without the use of powders. Consideration was given to sol-gel methods, polymer precursor systems, direct metal oxidation, biomimetic systems, and intertheme topics and problem areas (see Table 1). The Max-Planck, Office of Naval Research (ONR), and National Science Foundation (NSF)-sponsored workshop was held from November 19-23 at Schlos Ringberg, near Munich, FRG.

**Table 1. Presentations**

| | |
|---|---|
| **Sol-gel Processing** | |
| D.L. Segal, Harwell | B. Dunn, UCLA |
| H. Hausner, Technische Universität (TU), Berlin | A.J. Hunt, Lawrence Livermore Laboratory (LLNL) Berkeley |
| L.C. Klein, Rutgers University | M.L. Mecartney, Minnesota University |
| H. Schmidt, Saarbrucken | M. Yamane, Tokyo Institute of Technology |
| **Polymer Precursor Pyrolysis** | |
| P. Greil, TU, Hamburg | M. Seibold, TU, Hamburg |
| J.S. Haggerty, Massachusetts Institute of Technology (MIT) | L.V. Interrante, Rensselaer Polytechnic Institute (RPI) |
| R.M. Laine, University of Washington | T. Vaahs, Hoechst AG |
| D. Seyferth, MIT | R. West, Wisconsin University |
| R. Riedel, Max Planck | |
| **Direct Metal Oxidation** | |
| D.G. Brandon, Technion | H. Scholz, TU, Hamburg |
| N. Clausen, TU, Hamburg | A. Mocellin, École des Mines, Nancy |
| S. Somiya, Nishi Tokyo University | |
| **Biomimetic Systems** | |
| P. Calvert, Arizona University | |
| **Intertheme Topics and Problem Areas** | |
| R.J. Brook, Max Planck | L.C. De Jonghe, LLNL |

Following each of the sessions, summary groups in sol-gel processing, polymer pyrolysis, and direct metal oxidation were organized and their views of the conference topics were presented in the workshop review session. In counterpoint, a group of researchers active in traditional powder processing (termed *Powders Fight Back*) expressed long-range and industrial views of conventional powder manufacturing; i.e., press and sinter.

## Workshop Summary

The summary session consisted of two contributions--workshop summary and a roundtable discussion consisting of industrial and academic viewpoints. The five working groups and their chairs included

1. Direct Metal Oxidation - Dr. Brian Derby, Oxford
2. Sol-Gel Processing - Dr. John Engell, Technical University of Denmark
3. Polymer Precursors - Ralf Riedel, Max-Planck Institute
4. Powders Fight Back - Professor Gugel, Cremer Forschung Institüt
5. Long-range Vision of Powder Processing - Dr. Rishi Raj, Cornell University.

Individual chairs provided individual summaries.

The industrial and academic roundtable involved Drs. Daniel Broussaud of Rhone-Poulenc, Raj Bordia of Du Pont, Dr. Woditsch of Bayer. The academic viewpoint was given by Drs. David Brandon of The Technion, John Haggerty of MIT, and Professor João Baptista of Campo University of Portugal.

## Summary Session

If the summary session asked the question, "Can we process powder free?" The answer was basically "Yes." The issues in question related to the underlying economic, scale, and chemistry requirements. The session reflected on the limitations of the individual process routes and the viability in different market sectors. Applications can include films, fibers, composite structures, aerogels, powders, sensors, high-temperature superconductors, wear, and structural components. For processing powder free, several candidates' processing routes are competing: sol-gel processing, polymer precursors, powder processing, chemical vapor infiltration, and direct metal oxidation. The need exists for a cost-effective and reliable processing step which is critical to the success of the technology. The processing goal involves a homogeneous structure and uniform properties. Success can be achieved in many film and

fiber applications, but it was questioned for monolithic bodies. The requirements for full-density ceramics may not be an issue. In general, can reliable design properties and dimensional control be achieved for acceptance as engineering components?

The limitations of the current nonpowder-processed ceramics involve segregation, excessive shrinkage, flaws, and undesirable phases. The source of these inhomogeneities must be addressed in the initial steps of processing. It is questioned whether a post processing "cure" exists. For sol-gel and polymer precursors, a question was raised. "Can we scale nonpowder-processed products from films into three-dimensional monoliths?" At this point, there is not a sufficient and reliable database on the physical and mechanical properties versus powder-processed ceramics. In addition, the vested costs in powder-processed ceramics may limit implementation by the industrial sector. These candidate processing routes are seeking cost-effective applications of fibers, films, composites, and powders, and were considered promising.

## Working Group Summary

The three working groups provided presentations concerning the challenges, as well as the needed research stimulation for direct metal oxidation, sol-gel, and polymer precursor processing. The performance challenge of these routes was met directly by a working group summary termed *Powders Fight Back*.

**Direct Metal Oxidation.** The challenges in direct metal-oxidation process involved a lack of understanding of the reaction mechanisms for the formation of alumina and aluminum nitride; i.e., the incubation or nucleation and growth stages. The oxidation/nitridation products appear to be limited to aluminum matrix systems as well as composite structures. Very little understanding has been provided of the microstructure, mechanical property, processing relationships, and, particularly, the high-temperature performance. A recurrent theme was the "secrecy issue" with the very limited published literature available concerning the Lanxide® process. A need exists to enhance the elevated-temperature mechanical properties, also a greater understanding of the basic mechanisms of the reaction, the nucleation and growth of the spinel and oxide phases, and the diffusional controlled transport. The application of the direct metal-oxidation process to nonaluminum matrix systems; e.g., silicon and titanium, should be evaluated for their potential. Specifically, the production of titanium and zirconium nitride, as well as silicon carbide and silicon nitride via this route, would be of interest.

**Sol-Gel Processing Challenges.** Processing limitations appeared in the areas of shrinkage, control of pore formation, and distribution of porosity. In addition, the variety of processing conditions and variables do not provide clear guidance for effective utilization of sol-gel materials. The understanding of the amorphous-to-crystalline transformation, as well as the nucleation and crystallization kinetics, appear to be a deficiency in understanding. From the mechanical property point of view, the low-Weibull modulus was noted. To improve the understanding of the sol-gel processing, the following recommendations were made for understanding and process optimization:

- Enhanced role of the supercritical drying
- Control of shrinkage; i.e., theory of drying
- Control of porosity-via-physical vapor deposition and/or chemical vapor deposition
- Understanding of gel strength
- Evaluation of organic/inorganic phase behavior.

Sol-gel materials generally has been limited to one system; i.e., silica. Other systems should be considered; e.g., alumina. A novel approach to sol-gel processing involves incorporation of composite, optical, and piezoelectric materials. Approaches should be considered to give sol-gel materials a more functional application.

**Polymer Precursor Challenges.** For polymer-precursor-processed ceramics, similar deficiencies were noted as in sol-gel processing; e.g., pyrolysis shrinkage, product stoichiometry, transformations, and the role of residual porosity. A major issue involved the cost of both the sol-gel and polymer precursor materials. A need cited was the chemical design of the polymer precursor to match the final stoichiometric ceramic product. The current approach is driven by having candidate polymers, pyrolysis, and judgment of the quality of the ceramic yield and chemistry after synthesis. The polymer chemists should be tasked by the ceramic requirements rather than providing a current portfolio of precursors for pyroalysis analysis. A recurrent theme was that a closer relationship should be established between the chemist and the materials scientist.

Needs are seen in the polymer precursors for the following areas:

- More effective conversion of polymers to ceramics
- Role of precursors in joining of ceramics
- Process control and conversion during pyrolysis
- Elimination of pore shrinkage
- Polymer precursors for composite matrices.

An attractive approach is the role of the polymer precursors as possible matrix material with an appropriate filler. The process of active filler-controlled pyrolysis at the University of Hamburg attracted attention when incorporated with plastic forming and machining for the production of near net shapes after reaction pyrolysis. The addition of dispersions into the polymer precursors, as well as sol-gel materials to form composite structures, may prove attractive based on their shape-making capability and relatively low-processing temperatures.

**Powders Fight Back Counterpoint.** The working group involved in the standard powder-processing approach was termed *Powders Fight Back*. They were very confident about the future role of powders in ceramic processing. Monolithic ceramics formed by powders have a tradition of 15,000 years maturity to a current annual market value of 110 billion Deutsche Marks (DM) of which 18 billion DM were advanced ceramics. The industrial view indicated that powder-processed ceramics behave wonderfully. The knowledge gained and the accumulated experience in the cost-effective production and application will be difficult to replace. The technology in conventionally powder-processed materials is emphasizing decreased shrinkage, particle reinforcement, and *in situ* whisker formation. The powder approach acknowledged the need for new chemical techniques and it indicated that powder processing can be supported by only partial application of chemical routes, specific modeling of shapes with gels, plasticizers for extrusion and injection molding, dispersion of minor constituents, active powders, and polymer routes for fillers. There was a general acknowledgement that there are problems with powder processing; e.g., brittleness, and lack of design reliability. There was a need to minimize these through a better process understanding and to understand the design of the eventual product. These traditional problems of ceramic powder processing cannot be solved using new systems for processing. A better understanding of the traditional press and sinter approach would help. The conclusion of the powder-processing group indicated that the new chemical methods (sol-gel processing, polymer precursors, direct metal oxidation) should be further evaluated. However, more investigations into conventional powder processing are needed. As a result, the conventional ceramic powders do not have to fight or come back. They were actually never absent and will always remain strong--perhaps "powders uber alles."

## Industrial Viewpoint Roundtable Discussion

The second part of the session involved the roundtable discussion of industrial and academic viewpoints. Drs. Woditsch of Bayer, Daniel Broussaud of Rhone-Poulenc, and Raj Bordia of Du Pont led the discussion from the industrial viewpoint. From performance requirements, they stressed the need for an understanding of the relationship between flexural strength, high-temperature resistance, corrosion resistance, and fracture toughness of ceramic materials. In addition, the need for compound materials; i.e., composites with particle-, whisker-, and fiber-reinforcement were highlighted. The areas of nanocrystalline materials and amorphous materials should be scaled to larger components with cost reduction and product realization within this century. From the commodity viewpoint, vital ingredients were long-term corrosion resistance, reliability, processability, mechanical properties, and price. The price for performance of a material was addressed for sol-gel processing and polymer precursors. This shows a need for value-added surface coatings and binders for powders used for injection molding. Needs for reduced shrinkage coupled with better microstructural control and homogeneity were cited as process challenges.

Dr. Bordia looked at the reliability issues that can be improved on by ceramic matrix-composite reinforcements or heterogeneities. Monolithic ceramics often have composite microstructures and offer design flexibility in terms of dielectric substrates; e.g., variety of glass chemistries, fiber-reinforced composites, fibers, matrix, and surface coatings. In addition, powder surface coatings can be produced by a polymer precursor or sol-gel processes. A combination of powders and gels may offer unique and vast opportunities in the future. There was a discussion about a combination of conventional powder and nonpowder techniques, or a sol-gel, where polymer precursors are combined with powders, fibers, and particulates.

The majority of industrial participants looked at the impressive research effort in polymer synthesis and the understanding of pyrolysis. The sol-gel approach for nonsilica systems was encouraged. In particular, for transforming glass systems, there is caution about dimensional changes, porosity, and residual stresses. For glass ceramics, the question was raised whether amorphous materials be fully crystallized. The detrimental role of the residual glass phases was noted.

For "full-density" materials, residual porosity can be acceptable, provided it is well distributed. In many cases, the penalty for achieving 100 percent density is not very cost effective; residual porosity can be tolerated in certain applications.

The new emphasis on reactive ceramic systems indicates; i.e., direct metal oxidation, that it is a very interesting method with caution expressed about the degree of homogeneity, microstructural control, and porosity. The application of these systems to other nitride and oxide systems would be a particularly interesting development.

The reality of today is: many ceramic-processing companies have existing capital equipment and investment in traditional and established powder processing. Although this is challenged by nonpowder processing, the application of the current technology to sol-gel or polymer-precursor chemistry may not be financially acceptable. The revolution of nonpowder processed ceramics is not here; however, it will be an evolutionary cycle. The current ceramics have cost/performance ratios at a minimum in a consumer-driven market with strict quality requirements and defined targets. In the ceramic evolution, the use of sol-gel or polymer precursors can be used for forming vehicles, dopants of SiC, composite matrices, grain boundary control, or as the second phase dispersion. In addition, air handling of polymers would be a requirement. As a result, the industrial viewpoint expressed interest; however, it also was cautious and conservative.

# Marine Technology Directorate Research Programs

*by Michael J. Koczak*

## Overview

The Marine Technology Directorate (MTD) of the Science and Engineering Research Council (SERC) of the U.K. is a focused research directorate involved with five directed programs of marine technology:

1. Marine resources
2. Ocean structures and materials
3. Underwater working
4. Ship and floating structures
5. Physical ocean environment.

A brief description of the individual groups is provided with a summary of their funding profiles. The economic considerations of North Sea oil plus a need to respond to the commercial maritime interests are the needs that motivated creating the MTD. Nevertheless, the technology developed is of interest to both commercial, environmental, and defense needs. The MTD couples a research and education and training base with multiclient-sponsored projects in their portfolio. Table 1 provides a list of marine technology centers.

**Table 1. Marine Technology Centers**

| Name and Location | Coordinator | Focus |
|---|---|---|
| Cranfield Institute of Technology<br>Department of Materials<br>Cranfield, Bedfordshire<br>MK43 0AL<br>Tel: 0234-750111 | Professor J. Billingham | Underwater facilities, welding, offshore engineering |
| The University, Glasgow<br>Department of Mechanical Engineering<br>Glasgow G12 8QQ<br>Tel: 041-3390969 | Professor M.J. Cowling | Materials, structures, hydrodynamics |
| Heriot-Watt University<br>Institute of Offshore Engineering Research Park<br>Riccarton<br>Edinburgh EH14 4AS<br>Tel: 031-4495111 | Professor D.G. Owen | Mariculture, undersea automation |
| Imperial College of Science, Technology, and Medicine<br>Department of Metallurgy and Materials Science<br>London SW7 2BP<br>Tel: 071-5895111 | Professor P.L. Pratt | Fluid loading, floating production systems |
| Marinetech Northwest-The University of Manchester<br>Department of Liberal Studies and Science<br>Oxford Road<br>Manchester M13 9PL<br>Tel: 061-2752017 | Professor M. Gibbons | Marine environmental protection, waste management |
| University Newcastle upon Tyne<br>School of Marine Technology<br>Armstrong Building<br>Queen Victoria Street<br>Newcastle upon Tyne NE1 7RU<br>Tel: 091-2226000 | Professor J.B. Caldwell | Fluid structure loading, design, marine safety |
| University of Southampton<br>Department Of Ship Science<br>Southampton SO9 5NH<br>Tel: 0703-592316 | Professor G.J. Goodrich | Undersea acoustic research, hydrocyclones, ROVs |
| University of Strathclyde<br>Department of Ship and Marine Technology<br>100 Montrose Street<br>Glasgow G4 0LZ<br>Tel: 041-5524400 | Professor C. Kuo | Subsea operations, NDE |

## Marine Resources

The marine resources sector has 26 programs (see Table 2). Additionally, a managed program involves the treatment of water offshore includes the cooperation of several oil companies (e.g., BP, Amoco, Chevron). The SERC effort is coordinated at Heriot-Watt University. The total 1989/90 budget is nearly £1 million (90 percent is directed to oil and gas endeavors with the balance to mineral resources, energy, and bioresources).

**Table 2. Partial List of Marine Resources Programs**

| Group | Programs |
|---|---|
| Salford University | Petroleum and combustion |
| Liverpool University | Fluid flow |
| Birmingham University | Gas flow in viscous media |
| Heriot-Watt University | Treatment of offshore oil, modeling hydrocarbon plumes |
| Queen's University, Belfast | Wave powerstations |

## The Physical Ocean Environment

The annual 1989/90 budget is £378,000 in fluid loading, ocean environment, and coastal engineering. A managed program on fluid loading was designed to understand the dynamics of three-dimensional (3-D) wave action on cylindrical structures on fixed and compliant naval structures. A program of fluid loading, recently completed, had a budget of £850,000; it was sponsored by British Gas, Conoco, and BP, among others. Table 3 presents additional programs.

**Table 3. Physical Ocean Environment Programs**

| University | Programs |
|---|---|
| Newcastle upon Tyne University | Wave diffraction study |
| Brunel University | Vortex lattice techniques to submarines application |
| University College, London | Analytic simulation of flow around ship's hull |

## Ocean Structures and Materials

The largest level of funding (e.g., £2.6 million [1988/89] and £2.3 million [1989/90]) is directed into this effort which includes 45 projects and 6 managed programs. The topics include: structural integrity monitoring, defect assessment, fatigue, stress, buckling, grouts and grouting, corrosion and fouling, foundations and piling, welding and materials, concrete, other ocean structure (i.e., pipelines) design, and decommissioning of structures. Table 4 presents specific ocean structures and materials research topics.

**Table 4. Ocean Structures and Materials Research**

| University | Programs |
|---|---|
| Strathclyde University | Ultrasonic flooded member detection, artificial intelligence for nondestructive evaluation |
| Cranfield University | Structural integrity monitoring |
| Glasgow University | Defect assessment of offshore structures |
| University College London | Development of fatigue crack growth software (e.g., FACTS), corrosion fatigue |
| University of Surrey | Grouts and study of gel strength |
| University of Manchester Institute of Science and Technology | Hydrogen embrittlement |
| Cranfield Institute | Crevice corrosion in steels, high-strength quenched, tempered steels |
| University College London | Foundations and piling |
| Oxford University | Seabed pressures |
| Marinetech Northwest | Decommissioning of offshore structures, composite structures |

## Ships and Floating Systems

Ships and floating systems projects involve compliant systems, wire ropes and cables, shipping semisubmersible technology, and floating structures. The funding budget for the program was approximately £1 million in 1988/1989 and £700,000 in 1989/1990. The budget is funded approximately 50 percent from the SERC and 50 percent from other governmental and industrial sources. Table 5 provides a list of universities and their specific topics related to ships and floating systems research.

**Table 5. Ships and Floating Systems Research**

**University College London**
Passive station keeping, floating production systems with case studies
**City University**
Improved wire ropes and cables
**Portsmouth Polytechnic College of Maritime Studies at Warash Southampton University**
Modeling of fires in steel ships and offshore structures

Fire safety has received the majority of funding, presumably spurred as a result of the Piper Alpha disaster. The protection of steel pipes and panels has been an area of interest with the development of cementious and intumescent coatings. A program entitled SOFIPP 9 (i.e., Shell Offshore Fire Impingement Program) has been initiated to study temperature protection of piping to maintain a temperature of 300°C

for 1 hour. Reports concerning the program can be obtained for £30 from:

L.C. Shirell
Shell Research Ltd.
Thornton Research Center
P.O. Box 1
Chester CH1 3SH, U.K.

For further program details, contact

M.W. Payne
MaTSU, Harwell Laboratory
Oxon, OX11 0RA, U.K.
Tel: 44-235-435586

An Offshore Reliability Workshop was held at National Institute of Standards and Technology (NIST), Gaithersburg, Maryland, on March 20-22, 1991. Topical working groups included:

- Risk and reliability assessment
- Structures: risk and reliability issues
- Production facilities
- Pipelines and subsea systems
- Risk management practices.

For details, contact

Dr. Emil Simiu
National Institute of Standards and Technology
Building 226, Room B158
Gaithersburg, MD 20899
Tel: 301-975-6076
FAX: 301-975-4032

## Working Underwater

The area of working underwater involves diving, viewing, measurement, survey, communication, sub-sea automation, automation technology, and underwater working. The annual budget is £549,000 with the major areas of support involving subsea automation; i.e., £189,000, and underwater working; i.e., £193,000. Table 6 shows universities and their respective underwater projects.

**Table 6. Underwater Projects**

| University | Projects |
|---|---|
| University College London | Remotely operated vehicles Dynamics |
| Heriot-Watt University | Automation of sub-sea tasks via sensor interpretation<br>3-D imaging and modeling |
| Edinburgh University | Illumination of wave by laser interferometry |
| Strathclyde University | Cost effectiveness of sub-sea task automation |

## MTD-Managed Programs

Table 7 summarizes MTD-managed programs.

## Summary

The MTD is a relatively new multifaceted spin-off from the SERC administration structure with a portfolio of marine programs amounting to £5 million annually. The activities apart from the detailed research efforts include marine technology studentships, training and master of science courses, society for underwater technology, and international collaboration. European Community (EC) maritime efforts include:

- MAST - Marine Science and Technology Program under EC Directorate XIII
- WEGEMET - West European graduate education in marine technology
- IFREMER - Insitut Francais de recherche pour L'exploitation de Mer
- UETP - University enterprise training partnership

For further information, contact

The Marine Technology Directorate, Ltd.
19 Buckingham Street
London WC2N 6EF, United Kingdom
Tel: 44-71-321-0674
FAX: 44-71-930-4323

**Table 7. MTD-Managed Programs**

**Multi-Client Projects**
- Rational approach and guidance for effective underwater inspection
- Design and operational guidance on cathodic protection of offshore structures, subsea installations, and pipelines
- Dynamics of fixed marine structures
- Method for acceptance testing of underwater video

**Future Enabling Technologies**
- Materials in ocean environments (e.g., ceramics for machine parts, polymer coatings, marine adhesives)
- Sea surface support technology
- Subsea technology
- Ocean exploitation technology

**Programs Under Development**
- Analysis of hazards resulting from surface activities on subsea facilities and pipelines
- A guide to floating structures

**Special Topics**
- Environmental protection
- Waste management

**Defense-related Activities**
- Hydrodynamics
- Defect assessments
- Automation of subsea tasks
- Composites
- Robotics

# Energetic Materials: New Synthesis Routes, Ignition, Propagation, and Stability of Detonation

*by Ronald W. Armstrong, the Liaison Scientist for Energetic Materials and Propellants for the Office of Naval Research European Office. Dr. Armstrong is on leave from the University of Maryland, College Park, Maryland.*

## Introduction

The Royal Society has scheduled a discussion meeting on this topic for November 5-6, 1991, at Carlton House Terrace, London SW1Y 5AG. Professor Peter Gray FRS and Dr. John E. Field, University of Cambridge, have organized the meeting (Armstrong 1991). About 300 people are expected to attend. Posters covering all aspects of energetic materials research will be presented by invitation. For more information, contact John Field, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE, U.K., telephone 0223 337318. Table 1 presents the program.

**Table 1. Royal Society Discussion Meeting Program**

| Presenters | Topic |
|---|---|
| **Session I:** Chairman Peter Gray, Gonville and Caius College, University of Cambridge | |
| J.E. Field, N.K. Bourne, S.J.P. Palmer, and S.M. Walley, Cavendish Laboratory, University of Cambridge | Hot spot ignition mechanisms for explosives and propellants |
| Jagadesh Sharma and B.C. Beard, Naval Surface Warfare Center, White Oak Laboratory, Silver Spring, MD | Spectroscopy of reacted surfaces |
| J.N. Sherwood, D.B. Sheen and P.J. Halfpenny, Department of Pure and Applied Chemistry, University of Strathclyde, Glasgow G1 1XL | Dislocations in organic energetic materials |
| **Session II:** Chairman A.N. Dremin, Institute of Chemical Physics, U.S.S.R. Academy of Sciences, Moscow | |
| R.W. Millar, M.E. Colclough, P. Golding, P.J. Honey, N.C. Paul, A.J. Sanderson, and M.J. Stewart, Royal Armament Research and Development Establishment (RARDE), Fort Halstead, Kent TN14 7BP | New synthesis routes for energetic materials using dinitrogen pentoxide |
| A. Bailey, J.M. Bellerby and S.A. Kinloch, Royal Military College of Science, Shrivenham | Advances in bonding agents for polymer-bonded explosives |
| F. Volk, Fraunhofer-Institüt für Chemische Technologie, W-7507 Pfinztal-Berghausen, Federal Republic of Germany (FRG) | Energy output of insensitive high explosives by measuring the detonation products |
| W. Byers-Brown, Department of Chemistry, University of Manchester M1 7HS, and M. Braithwaite, Nobel's Explosives Company Limited, Ardeer Site, Stevenston, Ayrshire KA20 3LN | Analytic representation of the adiabatic equation for detonation products based on statistical mechanics and intermoleculare potentials |
| **Session III:** Chairman W. Byers-Brown | |
| A.N. Dremin | Shock discontinuity zone effect; the main factor in the explosive detonation,decomposition process |
| C.F. Melius, Sandia National Laboratories, Livermore, CA | The thermochemistry and reaction pathways of energetic material decompositions and combustions |
| T. Brill, Department of Chemistry, University of Delaware, Newark, DE | Condensed phase chemistry of explosives and propellants at high temperatures |
| P.G. Laye, Department of Physical Chemistry, The University, Leeds LS2 9JT | Experimental studies of propagation of combustion in solids |
| T. Boddington, The University, Leeds, and P. Gray | Theoretical studies of ignition and propagation of combustion in solids |
| **Session IV:** Chairman J.E. Field | |
| P.J. Haskins and M.D. Cook, RARDE, Fort Halstead, Sevenoaks, Kent TN14 7BP | Implications of many-body forces to equations of state at high pressure |
| M.M. Chaudhri, C.P. Constantinou, and T. Mukundan, Cavendish Laboratory | Factors controlling the sensitiveness of condensed explosives |
| G.A. Leiper, Nobel's Explosive Company (NEC) | Numerical modeling of the performance of explosives |

**Other Meetings**

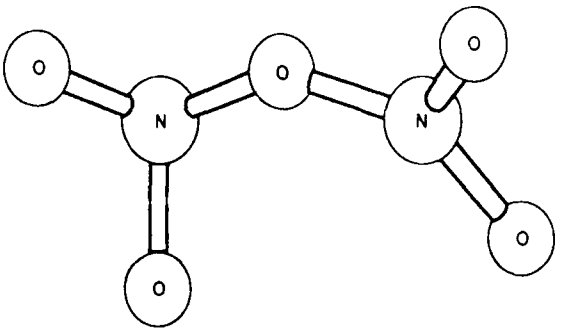
| Name | Date | Location | Contact |
|---|---|---|---|
| Ninth Symposium on Chemical Problems Connected with the Stability of Explosives | 12-16 May | Margretetorp, Sweden | Dr. Jan Hansson, Oskarsvagen 32, S-172 37 SUNDYBERG, Sweden |
| Sixteenth International Pyrotechnics Seminar | 24-28 June | Jonkoping, Sweden | Dr. Jan Hansson |
| Twenty-second International Annual Conference of ICT Combustion and Reaction Kinetics | 2-5 July | Karlsruhe, FRG | Conference Secretariate, Fraunhofer-Institüt für Chemische Technologie (ICT), Attn: Manuela Wolff, Joseph-von-Fraunhofer-Strasse, P.O. Box 1240, W-7507, Pfintzal (Berghausen), FRG |
| Second Beijing International Symposium on Pyrotechnics and Explosives Combined with the Seventeenth International Pyrotechnics Seminar | 28-31 Oct. | Beijing, People's Republic of China | Associate Professor Gong Jianguo Mechanics and Engineering Department, Beijing Institute of Technology P.O. Box 327, Beijing 100081 People's Republic of China |

## Site Visits

Several U.K. persons named in the program have been visited to provide additional information on their research interests.

**University of Strathclyde.** John Sherwood, David Sheen, and colleagues at Strathclyde have been involved for some time in growing very perfect crystals of trinitrotoluene (TNT), pentaerythritoltetranitrate (PETN), cyclotrimethylenetrinitramine (RDX), and cyclotetramethylenetetranitramine (HMX). The crystal perfections have been characterized by (transmission) x-ray diffraction topography (XRDT), using laboratory units at Strathclyde and with the x-ray beam line at the Daresbury synchrotron radiation (SR) source. A recent informative report, connecting with Kevin Roberts' appointment both at Strathclyde and the SERC Daresbury Laboratory, gives an overview of using SR for the structural characterization of crystallization processes, particularly for obtaining particulate products from solutions (Cunningham et al. 1991). Kevin Roberts has received a 5-year grant and advanced x-ray equipment at Strathclyde for research on crystal growth/characterization/property relationships. Otherwise, TNT, PETN, RDX, and HMX crystals are being tested in a deformation stage on the SR x-ray beam line. A main result is that the dislocations move only with great difficulty in any of the crystals, apparently because of steric hindrance effects associated with the interleaved nature of the molecules in the various crystal structures. The results are important because of the long-standing question of whether plastic deformation contributes to the decomposition of these crystals solely through localization of thermal heating from the plastic work.

**RARDE/Waltham Abbey.** Representing RARDE, Waltham Abbey, Ross Millar will present a description of their extensive work on nitration with dinitrogen pentoxide ($N_2O_5$). A picture of the busy molecule is shown in Figure 1. Golding, Millar, Paul, and D.H.




DINITROGEN PENTOXIDE
($N_2O_5$)

**Figure 1. Active molecule**

Richards have reported on reactions with mono- and di-oxacycloalkanes having 5-, 6-, and 7-membered rings (Golding et al. 1989) in the third of a series of articles that are to be six so far. Greville Bagg had reported on the move towards commercial $N_2O_5$ processing (Armstrong 1991). Other reports are available (Bagg et al. 1990, Arbor et al. 1990). Poly(3-nitrato-methyl-3-methyloxetane), known as polyNIMMO, bonded propellant has been used to give greater performance over conventional binders and have equal to, or less, vulnerability. Further information, including continuous production or nitration flow sheets, is available from Bagg (telephone 0992 713030). As reported (Armstrong 1991),

Waltham Abbey closed in April 1991. By June, those activities should be operational at RARDE, Fort Halstead, Sevenoaks, Kent TN14 7BP.

**Imperial Chemical Industry/Nobel's Explosives Company Ltd.** The Ardeer site of Nobel's Explosives Company (NEC) Limited, a division of Imperial Chemical Industry (ICI), is not far from Glasgow at Stevenston. Martin Braithwaite and Graeme Leiper are each involved in the planned Royal Society discussion. Dr. Ian J. Kirby is Research Manager of Defense and Aerospace Business. There are three research units. Casting Powder is headed by I.A. Duncan, Energetics is headed by W.B.H. Leeming, and Modeling is headed by Graeme. The NEC has 40 percent of the total world civil and defense explosives market including devices, gun propellants, and automotive air bags (initiated by sodium azide for complete inflation in less than 50 ms). The NEC bought Atlas Powder Company in the U.S. to provide for energetic materials production there. The ICI is scaling up a pilot plant to start in April 1991 to produce annually 500 kg of pure monomers via $N_2O_5$ for polyNIMMO or polyGLYN (glycidyl nitrate). Bill Leeming is involved with these novel materials, the nitration process, composite properties, and molecular modeling of interfacial wetting between the binder and energetic crystals. Leeming was positive about synergistic results coming from envisioned cooperative U.K./U.S. research activities. The indication is that poly-NIMMO can be matched with newer explosives. Graeme Leiper has been involved with the development of explosion models, hot spots associated with shocks, ignition insensitive properties, and laser ignition of explosives (connected with the Atomic Weapons Establishment). An example of shock/hot spot interest was the conclusion reached at NEC that the increase in shock pressure required to initiate smaller crystal particles was caused by the increased importance of thermal quenching at smaller sizes. The reversal of the size dependence for still larger crystals was attributed possibly to the reduced overall density of defect initiation sites on particle surfaces in compacts of the largest particle sizes. Relatively simple modeling work is done with the ICI code CPeX (commercial performance of explosives).

**Leeds University.** The involvement of the Leeds group in the discussion meeting relates to their research activities on pyrotechnic issues. Professor D. Baulch heads the School of Chemistry. He has been involved for a long time in compiling high-temperature chemical reactions. M.J. Pilling, previously at Oxford, is now Department of Physical Chemistry head and professor. He is interested in diffusion control of chemical reactions in dense (gaseous) systems. Peter Laye has a longstanding interest in thermal studies of pyrotechnic systems. He presented a plenary paper on the subject at the Fourteenth International Pyrotechnics Seminar, Jersey, U.K., (Laye 1989). His experimental facility is addressing the issue of matching (transient) kinetic measurements of reactant systems with static measurements of their thermodynamic properties, say, by calorimetry and thermal profile analyses. A recent consideration is that measurements of reaction velocities at several temperatures can be directly employed to describe pyrolytic behavior. An application of the work is to model calculations of kinetic and instability properties as developed in ongoing research by Terry Boddington. Recent joined work relates to gasless combustion transfer in mixtures of tungsten, potassium dichromate, and chromic oxide (Boddington, Cottrell, and Laye 1990), following on from an earlier paper. Boddington's approach of incorporating the chemical reaction heat source via Arrhenius-type kinetics into the heat flow equation carries over from his pioneering work on computing hot spot characteristics in the thermal decomposition of explosives, including PETN, RDX, HMX, and related materials. Recent work based at NSWC White Oak Laboratory, on the mechanical generation of hot spots in drop weight impact tests (Armstrong et al. 1990) has established a connection with Boddington's model. He expects that his part of such computations might usefully give order of magnitude estimates.

Others at Leeds have related interests in the subject. S.K. Scott has published with Peter Gray, formerly at Leeds, the book "Chemical Oscillations and Instabilities," *Oxford Scientific Publications*, 1990. At Leeds, there is a Center for Combustion and Energy Studies covering topics from short courses on fire and explosion to cooperative research activities. Professor Derek Bradley, Department of Mechanical Engineering, does coherent anti-Stokes Raman scattering (CARS) measurements and computational fluid dynamics. Professor Alan Williams, Department of Fuel and Energy, and Dr. John Brindley, Department of Applied Mathematics, are members.

Dr. John Griffiths, in Chemistry, does research on the spontaneous combustion of gases, aging of explosives, and catalyzed combustion of carbon fabric. A piston-driven high pressure chamber has been setup to study the adiabatic compression of a "bubble" with included gas for hot spot analysis. The aging of explosives-and-propellants problem is often associated with the loss of stabilizers that accumulate in voids. Griffiths has estimated a lower bound of 2.9 hours for the delay time to ignition of RDX at a supercritical temperature of 413 K (Griffiths 1990). Research on the catalyzed combustion of carbon cloth (Holme et al. 1988), sponsored through Fort Halstead by the Ministry of Defense, has possible application to infrared "deflection."

## References


Arbor, A., G. Bagg, E. Colclough, H. Desai, R.W. Millar, N.C. Paul, D. Salter, and M.J. Stewart. 1990. Novel energetic monomers and polymers prepared using dinitrogen pentoxide chemistry, *Twenty-first Annual Conference of the Fraunhofer-Institüt für Chemische Technologie*, Karlsruhe, in print.

Armstrong, R.W. February 1991. Synthesis of new explosives and binders within the new U.K. Defence Research Agency, *ESNIB* 91-02: 21.

Armstrong, R.W., C.S. Coffey, V.F. DeVost, and W.L. Elban. 1 August 1990. Crystal size Dependence for impact initiation of RDX explosive, *Journal of Applied Physics*, 68(3): 979.

Bagg, G., M.J. Stewart, W.B.H. Leeming, and P.F. Swinton. May, 1990. Manufacture of energetic binders using dinitrogen pentoxide, *U.S. Air Force Armament Division Conference: The Impact of Materials and Processes on Performance*, Eglin Air Force Base, Florida.

Boddington, T., A. Cottrell, and P.G. Laye. 1990. Combustion Transfer in Gasless Pyrotechnics, *Combustion and Flame*, 79: 234.

Cunningham, D.A.H., A.R. Gerson, K.J. Roberts, J.N. Sherwood, and K. Wojciechowski. January, 1991. *Quantifying some of the structural aspects of crystallization processes: experiments using synchrotron radiation*, preprint of the Daresbury Laboratory, DL/SCI/P737E.

Golding, P., R.W. Millar, N.C. Paul, and D.H. Richards. 1989. Nitration by oxides of nitrogen-III., *Tetrahedron Letters*, 30(46): 6431.

Griffiths, J.F. 1990. The prediction of a practical lower bound for ignition delay times, *Pyroteknikdagen*: 41.

Holme, I., J.E. McIntyre, A.F. Sykes, and J.F. Griffiths. 1988. Combustion characteristics of charcoal cloth impregnated with organic and inorganic oxidizers, *Eighth Symposium on Chemical Problems Connected with the Stability of Explosives*, 357.

Laye, P.G. 1989. Thermal studies of pyrotechnic systems, *Fourteenth International Pyrotechnics Seminar, Plenary Papers, RARDE*, Dorset Press, 1.

# PHYSICS

## Super Conductivity: Report on the Localization 1990 Conference

*D. H. Liebenberg, Scientific Officer for Condensed Matter Physics, Physics Division, Office of Naval Research, Washington, DC. Professor J. Price, Physics Department of the University of Colorado, Boulder, Colorado. Prof. Price was selected as an ONR Young Investigator, a Presidential Young Investigator by NSF, and is a recent recipient of the Lucile and David Packard award.*

### Introduction

Imperial College, London was the setting for the Localization Conference 1990 held August 12-14. Professor A. MacKinnon, Blackett Laboratory, Imperial College, London, was the host and managed to keep the participants well localized with a challenging program and nearby meals and accommodations.

This conference included a variety of important topics. A. Bending described a new topic addressing localization in an inhomogeneous magnetic field. The Levy experiment too opens a new and probably rich chapter in mesoscopics. What is the behavior of a single isolated ring? Can the persistent current effect be used to measure very small electron-electron attraction in nonsuperconducting metals? Realistic simulations of ballistic structures (including the random part of the potential as discussed by J. Davies), and experiments by C. Ford are new and important for the assessment of the technological potential of ballistic devices. Several experimental systems have been developed for the study of the metal-insulator (M-I) transition, including the persistent photoconductivity in AlGaAs:Si(dopant) - S. Katsumoto, Si:P system - Y. Nishio, thin films systems - J. Ketterson (Mo:C) and A. Goldman (Pb and Bi).

### Presentations

Sir Neville Mott provided the opening talk that both gave clear historical perspective to the conference and included his thoughts on superconductivity disorder and localization in the high Tc superconductors. Likewise, he particularly noted P. W. Anderson's paper which he stated is often quoted but little read. While the concept of a mobility edge is still useful, the phonons broaden the edge. The $La_{(1-x)}Sn_xVO_3$ has been shown by experiments to have a transition to metallic behavior at about the minimum in conductivity that he (Mott) predicted. However, Bergmann has developed an explanation involving quantum interference by multiple scattering at the Fermi surface that explains the data provided the scattering is elastic; i.e., scattering is by disorder. Altschuler and Aronov have provided a theory of the density of states (DOS), with interactions in a disordered conductor that gives a dip in the energy versus DOS at the Fermi energy. The quantum interference effect (QIE) grows and the conductivity goes to zero linearly. A minimum is not found because a low enough temperature has not been reached so phonons and magnons prevent quantum interference. This effect is also seen in the $Ge_{(1-x)}Cr_x$ films where Cr magnons damp the quantum interference below about 5 K.

N. Pounder et al., University of Leeds, UK, discussed resistivity and thermopower measurements. The $Nb_{(1-x)}Si_x$ amorphous alloy with $x=0.85$ Si is near the insulating transition where a crossover to a $T^{1/4}$ is suggested for the conductivity. For Si $x=0.82$, composition superconductivity is observed. Thermopower was measured; near the M-I transition, the value becomes very small and temperature independent. In the insulating phase, the thermopower has a small value and a quadratic temperature dependence. The QIE was discussed and is seen for samples only to $x=0.75$ Si. Both QIE and hopping must be considered near the M-I transition.

G. Dumpich, Duisburg University, Federal Republic of Germany (FRG), grew discontinuous gold films on carbon substrate films. These fractal films have a modified temperature dependence of the phase coherence length that is related to the percolating properties of the films. These films are less than 100 A and the diffusion distance scales with time to a critical power of $1/(2+\theta)$, with a value 1/2.87 rather than 1/2. From critical exponents, an argument was developed for a path restricted by the fractal nature of the film. The

phase coherence length is proportional to temperature to the power $-(p/2+\theta)$ where p is an integer. There was discussion as to whether the ac susceptibility should show a frequency dependence; an increase with frequency was suggested. These results have some similarity with the Sierpinski gaskets studied by A. Goldman, University of Minnesota, Minneapolis.

Z. Ovadyahu, Racah Institute, Hebrew University, Jerusalem, Israel, presented the second invited paper. Quantum interference effects were discussed in the hopping regime--magnetoresistance, conductance fluctuations--and (in multiply-connected regions) the periodic oscillations. The oscillations that vary with gate voltage may be because of the Coulomb blockade. The exponential variation of conductivity with temperature for different dimensions is

- One dimensional (1D), -1/2
- Two dimensional (2D), -1/3
- Three dimensional (3D), -1/4.

In indium-oxygen films that are crystalline but highly disordered, a 100-A thick film is in the 2-D regime while 1200-A thickness is in the 3-D regime. The hopping length is between 200-450 A. A chicken wire periodic arrangement is made. Consequently, at T < 1 K a 1D, relation is obtained. The giant periodic oscillations are related to QIE. A magnetic field introduced parallel to the film gives resonances that are related to a perpendicularly oriented field by a change of scale. A variation on the square (3,000-A length, 600-A line width) was made by placing a gate near one side of the square. Regular oscillations with gate voltage are seen and up to sixth harmonic in the Fourier transform. However, Ovadyahu believes this effect has little to do with the QIE. He also believes that it ends the search for h/e in highly disordered samples.

In another invited talk, Jean-Louis Pichard, C.E.A. Saclay, Gif-sur-Yvette, France, continued this topic of disordered conductors and dielectrics. He also discussed broken symmetries in this type of system. Changes in the localization length were related to the breaking of basic symmetry as when a magnetic field is applied or spin-rotation symmetry broken by spin-orbit scattering. The removal of time reversal symmetry results in a doubling of the value of the length while the length is halved by spin-orbit coupling.

W. Pook and M. Jansen, University of Köln, FRG, related various length scales to disordered systems with an M-I transition. In a high magnetic field, the technique for proper averaging was discussed when a log normal distribution obtains. Numerical simulations were shown.

J. Pendry, Imperial College, discussed the transfer matrix technique for calculating the transmission and reflectivity. He developed the case for the decomposition of a scattering region into a sequence of thin slices that have statistically independent matrices. Simplification results. As a consequence, a recursion relation for these slices is used to prove the independence of the limit as the number of slices goes to infinity. Also, the relation is true in 1-, 2-, and 3-D. A maximum fluctuation theorem was proved.

D. Belitz, University of Oregon, Portland, discussed spin susceptibility and the attempts to describe recent data. An effective field model for the disordered Fermi liquid was used to

- Find explicit exponents for the susceptibility temperature dependence in the metallic phase
- Suggest a new phase that precedes the insulator phase from the metallic side.

He also described a relation between high-temperature superconductors and disorder in 2-D where the spins and charge will act separately. The critical temperature is BCS (the J. Bordeen - L. Cooper - J. Schrieffer (BCS) theory is well known, Phys. Rev. 108, 1175 [1957]) like and the upper critical field is proportional to $Tc/T_{Fermi}$. The value $H_{c2}/Tc$ will be larger than the BCS model predicts. There were some comments on this model; it differs from the Wertheimer theory where the disorder suppresses superconductivity.

A. Lagendijk, FOM Institute for Atomic and Molecular Physics (one of the early investigators in the field) discussed the localization of light. He described the model system of titanium dioxide powder in suspension where the idea is to maximize the elastic scattering in contrast to the desires of most optical experiments. Correlation functions are measured between the important variables of angle, length, and wavelength or frequency. Experimentally, the frequency-frequency correlation is convenient while theorists prefer position-position correlations. Speckel is related to conductance fluctuations; dependence on the number of transmission channels excited was noted. Various measurement possibilities were described; e.g., a single beam into the scatterer and a wide-angle beam integrated output. The case for many beams has not been well measured. In the first case, the frequency shift should be related to $D/(\text{length})^2$. The spectra of the source has been measured in far field but is not the same as expected in near field. This consideration leads to a laboratory red shift that is small $10^{-3}$, and is velocity independent.

M. Kaveh, Bar-Ilan University, Ramat-Gan, Israel, continued with optical localization in a theoretical discussion of microstatics of optical waves in a random system. A polarization parameter was considered. Feynman trajectories were used to modify the usual Raleigh statistics that depend on the central limit theorem. As the width of the sample is narrowed, the new statistics showed long-range correlations and oscillations.

S. Schultz, University of California San Diego, provided convincing evidence for the advantages of

microwaves in studying localization. The insertion of well-characterized scatterers into the microwave cavity was discussed, including some sets of scatterers several meters in stacked length. Since the wavelength is macroscopic, the scattering material can be well characterized.

J. Dainty, Imperial College, discussed a 2-D problem addressed with unidirectional lines to generate roughness. The roughness is large compared to $\lambda$; a gold surface is used to provide reflection and a small penetration depth of the electromagnetic waves. Measurements versus angle are made and show the effects of multiple scattering and an enhanced backscattering. The cause of the enhanced backscattering is suggested to be a coherent cooperative effect similar to the enhanced backscattering associated with weak localization. While the agreement with predictions is good near the backscattering angle of zero degrees, there is less agreement at 10 and 40°. Suggestions of an effect caused by grain boundaries in the gold film were made, and complications with the slight penetration of the wave will be studied further. Phase conjugation with this technique was discussed since the illumination and return by backscattering would give phase conjugation which could be used to reconstruct an image that had passed through a disordered medium.

V. Feyliker, Institute for Radiophysics and Electronics, Kharkov U.S.S.R., described wave and electron localization by surface scattering using a technique to reduce the 2-D problem to a 1-D problem. He proved that electron and wave localization can be induced by boundary scattering. This approach will permit results to be calculated for microcontacts and multimode waveguides. A hierarchy of localization scales in such systems is suggested.

The second day brought an equally intense program of studies on a variety of solid-state systems. S. Katsumoto, University of Tokyo, Japan, began with the invited paper in which he described photo-induced, M-I transition in AlGaAs. At low temperatures, the deep levels have electrons frozen in but can be photo-excited. So experiments between 30-300 mK are given. On the metallic side, the conductivity obeys the $T^b$ law where the exponent b is between 0.3 and 0.6. The critical exponent is about 1; for the Hall conductivity, the critical exponent is about 2; the Hall coefficient remains finite at the critical density--n(c). On the insulating side, the temperature dependence agrees with the Efros and Shklovskii theory--tunneling vanishes for $n_c < 0.9$ and is finite near $n_c$.

A. Jansen, Max Planck Institute, Grenoble, France, gave results from the high-field magnet at Grenoble for bulk InAs and InSb. Fields up to 20 T and low temperatures to 50 mK were used to achieve the extreme quantum limit. The Hall effect does not depend on temperature, and in this respect is different from a magnetic field-induced M-I transition in a doped semiconductor. The value $(\rho)_{xx}$ decreases with temperature--a log T relation. He suggested that there might be an insulating state at T = 0 by extrapolating this dependence.

Y. Nishio, Tohoku University, Sendai, Japan, described the M-I transition in Si:P. The conductivity exponent at the phase transition is of interest since in many different systems, the value is near 1; for Si:P, the value is 0.5. In their experiments, the carrier concentration and random potential in both the metallic and insulating sides is controlled; in this case, the exponent is ~1.

L. Piraux, Catholic University of Louvain, Belgium, discussed graphite intercalates as ideal systems to display 2-D localization effects. Several elements have been successfully intercalated; the compounds show large anisotropy, and the inplane conductivity is high. An example of fluorine intercalated was shown; the ratio of conductivity in the plane to that normal to the intercalant planes was $10^6$. The fluorine causes disorder. However, the change from weak disorder to strong disorder can be controlled in this 2-D system. The resistance variation with temperature is shown to be power law, $R \sim T^{-x}$ where x = 1/3 over two orders of magnitude.

G. Bergmann, University of Southern Californian, Los Angeles, described the nonequilibrium metallic microstructures in the presence of high-current density (up to $10^7$ A/cm$^2$). This current corresponds to an electric field of about $3 \times 10^5$ V/m. Thus, the electron temperature is raised above the phonon temperature, and the relaxation is studied. While a calculation gives an estimate of relaxation time of $10^{-15}$ seconds, the actual relaxation is slower by 4 to 6 orders of magnitude. He has attempted to use the Coulomb anomaly to determine the temperature on a fast timescale, but it does not work. Results for a thin gold film and an indium film in a 7-T field were shown. The equilibrium curves of the resistance per square versus temperature have a log dependence. The assumption of one electron and one phonon temperature do completely describe the results. This work underscores that we lack a detailed understanding of electron relaxation by phonons when the system is inhomogeneous; i.e., a thin film on a substrate.

M. Schreiber, Johannes-Gutenberg University, Mainz, FRG, discussed numerical calculations of the electronic states in disordered systems, including the transport properties and their time behavior via diffusion. He summarized various numerical procedures. A calculation with a triangular lattice gave exponents that increase with the size of the box. The discontinuities of the derivatives for a box-shaped band edge may be important. A Gaussian shape was used; the exponent was

I. Varga, Technical University of Budapest, Hungary, has developed a universal classification scheme for the spatial localization properties of one particle eigenstates in finite d-dimensional systems. Electrons plus phonons are treated in a disordered system. In a finite system, it is difficult to distinguish extended and localized states. A relation is shown between the localization parameter and the information entropy of the charge distribution of the eigen-states. The relation is universal in the sense that it is independent of the geometrical atomic network, the lattice constant, and the size of the system, and depends on the decay form of the eigen-states and the dimension of the system. Similarities between 1-, 2-, and 3-D systems was shown.

H. Shore, San Diego State University, California, described a numerical method for dynamic response in Anderson localization and transport problems. A 3-D lattice of $(128)^3$ sites with a half-filled band was of interest. The current generated by an applied field was calculated for values of the disorder parameter less than the critical value $W_c$ on the metal side of the transition, near the transition, and in the insulating state. On the metallic side near Wc, the decay of the current follows a power law $t^{-1/3}$. Rescaling along the lines of Shapiro and Abrahams, the smallest dispersion of the calculated data is obtained with $t^{-1/2.9}$ and $Wc = 16.5$. A caution to experimentalists who are fitting data was provided by doing a general least-squares-fit to the data and showing that with three parameters, the data give $t^{-1/2.6}$ $Wc = 17.5$ (significantly different from the previous, more-constrained fit). Data very close to Wc is needed.

O. Viehweger, Max-Planck Institute, Stuggart, FRG, discussed the Hall coefficient in localization regimes in high magnetic fields. They used a model of independent electrons in the tail of the lowest Landau level for the 2- and 3-D systems. They find the xx component of the Hall conductivity diverges as frequency goes to zero, while the xy component becomes frequency independent. These results agree with the experimental data on n-doped, uncompensated 3-D semiconductors where the xx component divergence indicates the M-I transition while R(H) remains finite with increasing field. A discussion was given of the application of these ideas to the quantum Hall effect (QHE) and they obtained the frequency dependence to agree with experiments. At microwave frequencies, the flat plateaus are not observed.

In an interesting talk, M. Buttiker, IBM, Yorktown Heights, examined the transmission theory of electrical resistance. The problem is viewed as a transmission and reflection problem for a system with few quantum channels. The Onsager relations and reciprocity theorems are used, and the phase shift must be considered. This leads to the subtle differences in what voltage is measured in a four-contact probe arrangement where the current voltage leads are differently configured. The approach has been extended to the QHE, and high-field transport has provided sensitive tests of the theory. Fluctuations were discussed; the correlations of voltage fluctuation vanish in this theory, although white noise remains. Both shot and Nyquist noise were obtained in appropriate limits from this Buttiker-Landauer theory.

C. Ford, Cavendish Laboratory, described the ballistic transport measurements in high-mobility wires and junction with electron mean-free paths greater than wire dimensions and mobilities of $11 \times 10^6$. Electron motion across the channel has discreet levels, while along-the-wire motion is unconstrained. Results of an electron Fabry-Perot interferometer were shown and can be used to measure carrier concentration. A narrow wire with voltage probes on each side has a quenched Hall voltage at low magnetic fields if the junction of the wire and probes is nominally square. However, variations in shape cause the Hall resistance to be quenched, enhanced, or even negative. The explanation was described in terms of electrons scattering off the edges in specific ways. The results were shown on a single device changed by squeezing.

J. Davies, University of Glasgow, UK, reported that he had calculated the "quantum point contact" conductance by realistic potentials. The potential from the gate on the surface and that from the ionized donors (whose random positions are included explicitly) were included. The conductance of a 0.2-$\mu$m constriction is well quantized. For a 0.6-$\mu$m constriction, there is significant noise that can be included but it spoils the quantization.

Y. Takagaki, Osaka University, Japan, described ballistic electron transport in crossed-wire junctions. A variety of voltage current configurations was shown, and the variation with magnetic field was displayed. The transport coefficients are classified into two resistances that described the data--a Hall resistance and a bend resistance.

M. Fisher, IBM, Yorktown Heights, described theoretical work on the boson localization and superconductor-insulator transitions in films. The universal conductance in 2D was developed in a review of localization theory. There remains significant experimental discussion of this value. A scaling theory was developed for zero temperature, superconductor-insulator transitions in disordered films. In the insulating state, a description in terms of localized (Cooper pair) bosons is found to work. At the transition, an intermediate metallic state is predicted, with this finite universal resistance in the 2-D system. The physics of vortices was discussed in terms of a Hubbard-like model where the vortices are treated as quantum particles with Bose statistics. Bose condensation gives an insulating state. In a magnetic field, there is flux creep that leads to a resistive tail. With short-range interactions, a glass-like

1.15. A square lattice of 100 x 100 does not see localization but rather a speckle pattern is obtained.

T. Ohtsuki, Tohoku University, described Anderson localization of multilayered systems in a quantizing magnetic field. The conductivity exponent near the critical density was 1 even in high magnetic fields. The localization length exponent was 2.3 in 2D. A model for 3D was made by allowing hopping between layers. The localization length was found to be independent of the hopping term. There is a finite extended state region around the Landau sub-band center; the result is similar to the B = 0 case.

C. Adkins, Physics Department, Cavendish Laboratory, Cambridge University, UK, discussed conduction in granular metals. The activated conductivity cannot be explained yet. The basic theory of Neugebauer and Webb has the wrong temperature dependence. On the insulator side, this activated conductivity is discussed in other models such as island charging; but again, these models fail. After some 30 years of study, a good theory for the conduction in granular metals is still not understood. The talk certainly provided an informed assessment of the present theoretical situation. The problem of an electron spreading in a disordered 1-D finite conductor with a bias electric field is exactly solved. The localization length is determined and the general features of the M-I transition are found and may be interpreted in terms of a log normal distribution of relaxation times.

Y. Octuka, University of Tokyo, reported on the static magnetic susceptibility of doped semiconductors across the M-I transition. Both Si:P and Ge:Sb were measured over the temperature range 10 mK to 4.2K; an average field of 50 G was used. The paramagnetic deviation of susceptibility was observed for both insulating and slightly metallic compositions. A pair approximation model was used to obtain the temperature exponent of the susceptibility (chi) $\sim T^{-4/5}$ in the metallic region or a localized region value of $T^{-0.5}$. The data have a power law exponent of 0.4, 0.28 which are closer to the results for localization. sdI refer to $T^{-0.5}$ above as localized region, this experiment is closer to 0.4, 0.28 than is 0.8 in the metallic region.

S. von Molnar, IBM, Yorktown Heights, New York, reported results of localization and the M-I transition in magnetic semiconductors. The presence of magnetic impurity ions gives a magnetization that changes the electronic properties through spin exchange interactions between local magnetic moments and the carriers. An interesting system is $Gd_{(3-x)}V_xS_4$ where v is a vacancy. Above a critical field at low temperatures, the magnetoconductance was observed to be linear in H. The magnetic polaron, a region of aligned spin in the neighborhood of a charge carrier, represents a localization in a magnetically disordered or antiferromagnetic environment. About 50-Gd atoms are within the 10-A localization length. At the higher fields, the localization length increases so that the interaction can be tuned. This concept seems to explain the results and serves as a guide for other systems such as EuTe and HgMnTe. For the model system, the magnetoresistance was always negative. New results were reported for $Cd_{0.4}Mn_{0.6}Te$ which is insulating near the M-I transition. The conductive state is generated by exciting persistent photoconductivity at sub-band photon frequencies. Both positive and negative magnetoresistance is observed at increasing fields. Deviations from the zero field-temperature power law $T^{-1/2}$ dependence on log resistivity are found in the intermediate field range and at temperatures below about 140 K. The temperature dependence of the magnetoresistance does not scale down to 0.5 K with the bulk magnetization. That suggests that transport measurements in the insulating phase are sensitive to microscopic magnetic responses when the hopping length is sufficiently small.

S. Bending, University of Bath, UK, presented evidence for weak localization in a strongly inhomogeneous magnetic field distribution by developing a multilayer structure of a semiconductor and superconductor. The GaAs/AlGaAs heterostructure was the substrate for different type II superconductors. The 2-D electron gas is electrically decoupled from the superconductor. Magnetically coupled with the type II, an inhomogeneous field structure is established with vortices at field $H_{c1} < H < H_{c2}$. At low fields, the vortex density is low and the conductance increases linearly in contrast to the $B^2$ behavior in the homogeneous case.

V. Amaral, University of Porto, Portugal, discussed the weak localization and magnetism in amorphous rare-earth transition metal alloys. The DyYNi system was observed; YNi is nonmagnetic; and the doping leads to a shift by field-disordered scattering. Measurements between 1.4 and 20 K with fields to 10 T were used. The resistivity change of YNi was always positive and characteristic of weak localization. The doped samples show a positive contribution but have a superposed negative magnetoresistance caused by scattering from the Dy ions. This scattering saturates at about 5 T. A large increase in the slope of the initial positive change is because of the enhanced spin-splitting term by the Dy ions.

V. Kravtsov, University of Wurzburg, Wurzburg, FRG, offered another discussion of light propagation in a disordered medium. The nonlinear polarization term, proportional to the electric field cubed, was used, together with Maxwell's equations, to obtain the backscattered light. A dip in the returned light at $0^o$ was found. For weak localization, a frequency shift is identified. For strong localization, the light will not propagate.

state is found. In the superconducting phase, the bosons condense and the vortices localize. In the insulating state, the vortices condense and the bosons localize. Some comparison with experimental data was shown.

C. Lambert, University of Lancaster, UK, discussed localization by Andreev scattering in short coherence-length superconductors. Two models were described. In the first the magnitude of the order, the parameter varies randomly, but the phase is constant. In the second, the phase varies randomly but the magnitude is constant. In 1D for both models, all states are localized. In 2D for the first model, all states are localized. In the second model, the phase alone is not sufficient to localize quasi-particles. A new charging effect is predicted associated with order-disorder transitions in short coherence-length superconductors and superfluids. This effect arises from the Andreev scattering, does not conserve quasi-particle charge, and should accompany, for example, the melting of an Abrikosov flux lattice in a high- Tc superconductor. The effect might be detected via the thermal conductivity since only the normal quasi-particles carry entropy.

J. Ketterson, Northwestern University, Evanston, Illinois, described experiments with a superconducting insulator transition in Mo-C. This system has experimental advantages because good quality films, without island formation, can be grown and have a transition temperature at a critical thickness of 13 A. The threshold sheet resistance was found to be 2.8-3.5 $k\Omega/^2$ or a factor 2-3 less than the universal resistance. The variation with temperature was power law, $T^{-n}$, for 8-10-A film and stretched exponential, $\exp((Ti/T)^n)$, for the 6-7-A film. Values of n do not match the theoretical predictions.

A. Goldman, University of Minnesota, discussed superconductivity in the 2-D limit (a possible superconductor-insulator transition). He used a c-axis-oriented DyBaCuO film and ultra-thin, quench-condensed Bi and Pb films. For the high-Tc films at less than 40 A, there is an oxygen loss that can be controlled by temperature. This oxygen loss changes the localization so the whole transition can be studied with a single film. A sheet resistance close to the universal value is found that divides the insulating from the superconducting behavior as determined from the experimental R(T) curves. A separatrix between sets of curves was identified. Also in the DyBaCuO films, grains do not form until the thickness is greater than about 100 A, so epitaxial films are used in these experiments.

L. Levy, AT&T, Murray Hill, New Jersey, described persistent currents in mesoscopic rings. The experiments were done on an array so only ensemble-averaged effects were seen. Ultrasensitive magnetization measurements were taken on an array of $10^7$ isolated, mesoscopic copper rings. The persistent current of about 2-n Amp is obtained for a 600-A-wide, 300-A-thick film on a 2-m loop. The current has a nonzero ensemble average of the order $3x10^{-3}$ $ev_F/L$ and is periodic with applied flux with a period h/2e and not h/e. The amplitude of the current decreases exponentially with temperature on the scale of the correlation energy--about 80 mK. Diffusion is considered, and the defects cause a phase spread. While theories can explain the period h/2e, the amplitude is not explained.

U. Eckern, Kernforschungszentrum, Karlsruhe, FRG, described calculations of the electron-electron interaction and the equilibrium current of isolated rings that is found to be periodic with flux as h/2e, or units of 1/2 flux quantum. The magnitude is $I \sim ev_F l/L^2$ where l is the mean free path and L is the circumference of the ring. Interference between time-reversed paths, as in the theory of weak localization, is a crucial ingredient. However, interactions are also essential. The temperature scales exponentially with a value, as determined by the coherence energy $\sim hD/L^2$, that is near the 80-mK experimental value.

G. Montambaux, University of Paris South, France, gave results of computations of ensemble averages of persistent currents in mesoscopic rings that obtained a periodicity of h/2e using both analytical and numerical methods. In contrast to U. Eckern, this theory is based on noninteracting electrons. In the diffusive regime, the average is only slightly reduced compared to the typical current of $ev_D/L$. These results also fit the experimental data fairly well.

Y. Imry, Weizmann Institute, Rehovot, Israel, gave a summary talk. He divided the interests into topics: novel effects, classical results, metal/nonmetal systems, ballistic phenomena, and interactions with superconductivity.

Two theories have been put forward: one based on interaction (Eckern & Ambegaokar) and one based on independent electrons (Bouchait & Montambaux). Both give a flux periodicity of h/2e or $\phi/2$. Both give an amplitude for the current in disagreement with experiment. In BCS theory, the Coulomb interaction can be reduced by a factor 10--does copper superconduct? It must be very close. The correction to the potential is calculated, and the current average depends on the level spacing. This is a general result not just for rings, but for example quantum dots. The orbital susceptibility versus L has a large paramagnetic peak in contrast to a naive expectation of a negative value going to zero monotonically.

The summary of novel effects includes the Aharonov-Bohm and the Coulomb effects near the M-I transition where theory is not yet in good shape and experimentalists should beware. Inhomogeneous systems are also a problem, and theory needs to provide us a better understanding. Some classical effects are well understood such as fluctuations and spectral patterns

from noninteracting waves. The M-I transition theory is a complete mess. The experiments are better but is the Hall effect critical or not? Density-of-state analysis and relaxation to the alleged Coulomb gap is not complete. Is the critical exponent 1/2 or 1? Experimentalists should try to give the best value and not force it to a theoretical model.

Other exponents were discussed. The ballistic processes are rather well understood, but they lack interaction effects. Was the Hall effect quenching fundamental--how to make the quantization more robust? The superconductivity interaction with localization involves fluctuations, the Andreev reflection, the inhomogeneous B field introduction into samples, the SN and SNS systems, and the relation to charges. Scaling theory is still an assumption. Therefore, the attacks on it do not appear to be justified.

## Comments

The conference ended on a note that while much had been accomplished, both theoretically and with many detailed experiments, there are many open questions. These questions should indicate the vigor of this field, and new results should stimulate the next localization of these extended (and sometimes over-extended) researchers.

# PSYCHOLOGY

## Workshop on Computational and Biological Models of Visual Processing

*by Ellen C. Hildreth, an Associate Professor in the Massachusetts Institute of Technology (M.I.T.) Department of Brain and Cognitive Sciences, and Codirector of the Center for Biological Information Processing in M.I.T. Whitaker College of Health Sciences and Technology, and Vincent Torre, a Professor in the Department of Physics at the University of Genoa, Italy.*

### Introduction

The interdisciplinary study of computer and biological vision has emerged as a vital area of research that has led to substantial advancement in our understanding of natural and artificial vision. The excitement surrounding this field has been fostered by several major funding programs in North America and Europe, and by many conferences, workshops, and courses that highlight these achievements.

An international scientific workshop on Computational and Biological Models of Visual Processing was held in Trieste, Italy, on February 26-28, 1990. The meeting was jointly sponsored by the Office of Naval Research and the International School for Advanced Studies in Trieste, and brought together 35 invited researchers from North America and Europe, drawing from psychologists, neurophysiologists, and computer scientists.

The meeting goals were to

- Identify interesting problems for future research
- Explore new theoretical approaches to these problems, as well as new experimental paradigms and technologies for perceptual and physiological investigations
- Foster possible future collaborations between North American and European scientists with common research interests.

Three problem areas were chosen for the scientific focus of the meeting:

1. Analysis of visual motion and its use in tasks such as navigation
2. Integration of multiple visual cues
3. Higher-level aspects of vision such as attention and recognition.

These areas form a major focus of current work in computational vision. An open discussion considered the scientific impact of this interdisciplinary approach and its future directions.

This report first briefly summarizes the specific research accomplishments that were presented within the focus areas. Following this summary, we provide a more general perspective on the meeting accomplishments.

### Summary of Research Presentations

In his introductory remarks, Vincent Torre emphasized that the field of computational vision differs from classical theoretical and experimental disciplines, such as physics and neurobiology, in ways that ultimately require a different set of evaluation criteria. This is partially because it is very difficult to design experiments to prove or disprove conclusively a computational model. Although one cannot follow the traditional hypothesis-and-test scientific methodology, research in computational vision can still exhibit scientific rigor and yield significant scientific advances. For this to happen, however, we must adopt a rigorous set of evaluation criteria.

Torre suggested the following five criteria for evaluating a proposed computational model. The model should

1. Give insight into the nature of the problem and possible solutions
2. Be formally correct and consistent in a mathematical sense
3. Be implemented and tested on a wide range of synthetic and natural images
4. Be biologically plausible, in that its behavior is consistent with known physiological and anatomical properties of the visual system and its

implementation does not rely on highly specific networks to compute odd mathematical quantities
5. Suggest useful, relevant experiments for psychophysical or physiological investigation.

The following sections briefly summarize the specific research results presented by individual participants within the three areas of focus chosen for the meeting. Later in this report, we provide a more general assessment of the state of current research considering the above criteria.

## The Analysis of Visual Motion

The analysis of visual motion has been a major focus of work in computational vision, and an area where there has also been strong attempts at integrating theoretical and experimental work. The research presented at this meeting spanned a range of problems including the measurement of image motion and recovery of the three-dimensional (3-D) structure and motion of object surfaces and the movement of the observer. The talks also presented a spectrum of computational algorithms, innovative technology, new theoretical approaches, and interesting physiological work.

C. Koch's work at the California Institute of Technology, Pasadena, has focused on the problem of motion measurement. He first presented a new multiresolution algorithm for computing the two-dimensional (2-D) velocity field from the changing retinal image. His previous work had explored a single resolution algorithm, both in software and in VLSI hardware, that combined an optical flow scheme proposed by Horn and Schunck with discrete line processes that extend the algorithm to cope with motion discontinuities. Such single-resolution algorithms can reliably detect movement only over a limited range of speeds. The extension to a multiresolution algorithm expands the range of velocities that can be measured and increases the speed with which motion information can be integrated over an extended area of the image. Unlike previous multiresolution motion measurement schemes, Koch's algorithm allows the independent analysis of multiple motions superimposed at different scales, as in the case of transparency. The scheme is adaptive in that it chooses scale locally based on an estimate of the relative error in the velocity computation.

Koch also discussed implementing various stages of the motion measurement computation in primate visual cortex. In particular, he presented the results of computer simulations with a model that attempts to capture detailed aspects of the neuronal processing of motion from the retinal ganglion cells through the geniculate and early stages of cortical area V1. The model exhibits behavior similar to the behavior of cortical neurons for properties such as orientation and velocity selectivity. An example of the behavior of the model, compared with real neuronal responses, is shown in Figure 1.

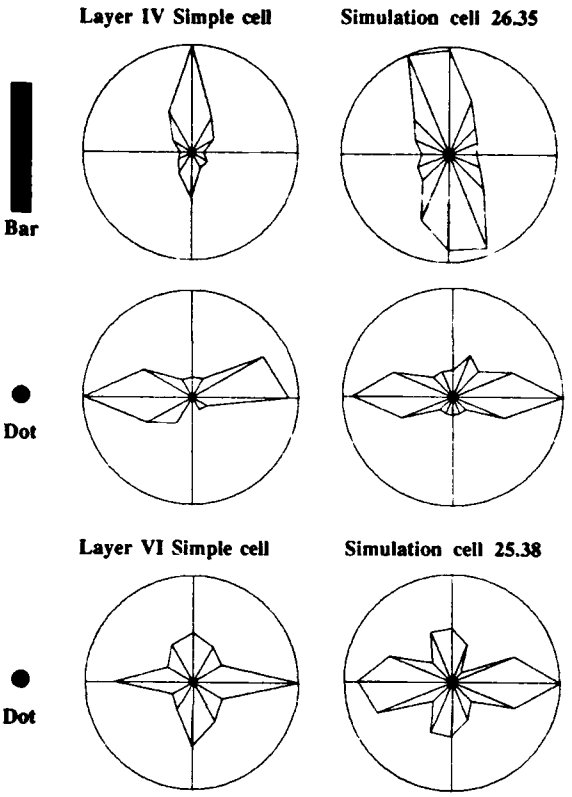



**Figure 1.**

Physiological responses of real cortical cells to moving bars (top row) and dots (bottom two rows) are shown on the left, and results of computer simulations with Koch's model are shown on the right. (Reproduced from F. Worgotter & C. Koch, *Modeling Visual Cortex*, manuscript submitted for publication.)

H. Nagel, Fraunhofer Institute für Information und Datenverarbeitung, Karlsruhe, Federal Republic of Germany, addressed the theoretical properties of optical flow algorithms that are based on using so-called smoothness functions, together with a constraint that relates local velocity to the spatial and temporal derivatives of image intensity. Many proposed algorithms compute a velocity field that minimizes some measure of the variation of velocity within regions of the image. Nagel has stressed that such measures should consider the local variation of intensity in the image. For example, strong intensity edges in the image represent potential locations of object boundaries, across which motion could change discontinuously. One can use the spatial gradient of image intensity to adjust the local measure of smoothness of the flow field to allow greater variation across such edges.

Several researchers discussed new theoretical approaches to the recovery of 3-D structure from motion. For example, A. Verri, University of Genoa, Italy, discussed recent work that he has conducted with Torre that uses the theory of planar dynamical systems as a basis for understanding this recovery. The 2-D motion field on the image plane can be seen as the flow vector of the solution to a planar system of differential equations. Singular points of the motion field, which are points where the field vanishes, and the time evolution of their local structure capture essential features of 3-D motion that enable translation, rotation, and general motion to be distinguished. In addition, it allows the computation of relevant motion parameters. Verri discussed how various components of the flow field, such as rotation, expansion, and shear, can be computed from simple measures of the spatio-temporal derivatives of image brightness. He also addressed the biological feasibility of this model by suggesting how these components can be computed through interactions between neurons with simple receptive field properties.

O. Faugeras, INRIA Sophia-Antipolis, France, presented a new theoretical approach to the analysis of the motion and structure of 3-D curves. His approach considers properties of the 3-D spatio-temporal surface formed by stacking together successive 2-D views of a curve moving through space. He first assumes that the curve maintains its 3-D arclength over time, a more general assumption than rigidity. Moreover, the curve shows that, in general, the full 3-D velocity field associated with the curve's motion through space cannot be recovered fully from this spatio-temporal surface. He then presented a method that uses the rigidity assumption combined with measurements of local differential properties of the curve to recover its 3-D structure and motion.

J. Koenderink, University of Utrecht, the Netherlands, presented a new theoretical framework for analyzing 3-D motion and structure, which is based on using affine geometry rather than the more standard euclidean geometry. Two surfaces that are related to one another by a rotation, deformation, and shear have the same affine order, which in principle can simplify the recovery of the 3-D transformation between them. He defined an affine velocity space and showed that the flow vectors in this space have a simple geometry that can be directly interpreted in terms of properties such as depth. His theoretical analysis suggests possible algorithms for recovering structure-from-motion from an affine representation of the flow vectors.

A. Blake, Oxford University, U.K., presented a technique for recovering the 3-D curvature of a surface along its silhouette using local measures of small differential motion along the image projection of its bounding curve. He derived a theoretical relationship between local surface curvature and the relative acceleration of image features across an edge. In addition, he designed an algorithm based on this relationship to derive curvature from computed measures of feature acceleration. One of the goals of this technique is to extrapolate the 3-D shape of a surface slightly beyond its visible parts for tasks such as manipulation. The model can also provide a qualitative classification of an object boundary as a sharp discontinuity in depth or smoothly curved surface.

The work presented by E. Hildreth, M.I.T., considers the hypothesis that the human visual system uses specialized processes to extract limited, but critical information about the 3-D structure and motion of objects and observer through the environment for visually-guided navigation. One such critical piece of information is the 3-D direction of motion of the observer relative to object surfaces. With regard to the computation of observer heading, she presented an algorithm based on a model that embodies three simple operations

1. Computation of the differences in velocity of moving features within small image regions
2. Extraction of the dominant direction of these local velocity differences
3. Computation of the intersection of these dominant directions to obtain an estimate of the location of the focus of expansion of the image velocity field, which indicates the observer's direction of heading.

We know from perceptual studies by Warren, et al. that human observers can judge their direction of heading with a very high precision of 1-2 degrees of visual angle under a range of experimental conditions. In general, this precision increases with increased speed of motion of the observer, with increased range of depth variation in the scene, and with an increase in the size of the field of view. The results of computer simulations with the visual patterns used in perceptual studies show that the above algorithm can achieve human accuracy at computing heading direction under the particular conditions of the experiments. The algorithm also fails in ways that the human system fails. For example, we cannot judge our direction of heading when moving perpendicular to a flat plane, if the visual flow pattern simulates both rotation and translation of the observer. The algorithm similarly fails in this case, as it relies critically on the presence of variation in depth. Several further predictions for perceptual studies were also presented.

The physiological mechanisms underlying motion analysis have been studied extensively in a wide range of species from insects to primates. In an effort that attempts to build a strong bridge between physiology and technology, N. Franceschini, CNRS, Marseille, France,

has designed and built a device that simulates the early motion detecting stages in the fly visual system. His work first explored the physiological responses of neurons in the fly visual system from the photoreceptors through the lobular plate neurons that feed motion signals directly to motor control centers. These experiments use very exacting equipment that allows the stimulation of individual ommatidia on the fly's eye. From a model of the physiological circuitry underlying motion analysis, a device was built to simulate this circuitry using electro-optic technology. The task of building and testing this device provided a rigorous test of Franceschini's model of the underlying circuitry, as well as suggested further physiological experiments to resolve open questions regarding the fly's circuitry.

A major recent finding regarding higher levels of motion analysis in primates is the discovery of so-called nonclassical receptive fields. The classical receptive field refers to that area of the visual field where light stimulation directly influences the response of a cell. The nonclassical receptive field refers to a larger surrounding area where light stimulation influences the cell's response only when presented simultaneously with stimuli in the cell's classical receptive field.

G. Orban's work at Catholic University, Leuven, Belgium, addresses the functional role of the nonclassical receptive field in the middle temporal (MT) area of the monkey visual cortex (site of motion analysis) and its analogous area in the cat. He studied the response properties of cells to stimuli consisting of moving bars of light surrounded by a random-dot texture in which the contrast, size, direction, and speed of motion of the bar and surrounding pattern were varied. He also correlated various cell types with their anatomical locus to determine whether they represent a function that is performed closer to the input or output layers of area MT. Orban classified the cells depending on the nature of their responses into groups associated with three computational roles:

1. Segmentation process that detects discontinuities in visual properties such as direction or speed of motion, which may underlie the localization of object boundaries
2. Region growing process that identifies large areas with homogeneous visual properties
3. Analysis of higher-order motion properties such as gradients in the velocity field, or characteristic velocity patterns corresponding to pure rotation or expansion of the visual field.

Detection of the latter properties may underlie the analysis of self-motion. Until now, the stimuli used in these experiments have been very artificial, usually consisting of moving random dots. Orban is currently developing the display tools to explore the responses of these cells to patterns of movement that arise more naturally when the animal moves through his environment. This is an effort to understand further the role these cells may play in the computation of observer motion.

W. Newsome's work at Stanford University, Stanford, California, addresses the relationship between the response properties of individual neurons in primate visual cortex and the overall behavior of the animal. The establishment of such a connection is essential for interpreting the responses of individual cells in terms of abstract computational functions for the animal. Newsome's work has shown that for a simple task in which an awake monkey is trained to detect the direction of motion of a visual stimulus, one can directly alter the behavioral response of the animal by stimulating individual directionally selective neurons in area MT.

Using a very different approach toward relating underlying physiology with functional behavior, L. Vaina, Boston University, has worked with human patients with parietal lobe lesions who exhibit characteristic deficits in measuring and interpreting visual motion. By characterizing the nature of their behavioral losses, she hopes to shed light on the organization of the underlying computations. In addition to a battery of standard psychophysical tests to assess patients' spatial vision, color vision, and motion sensitivity, she uses visual stimuli that test their ability to discriminate the shape of objects. The shape boundaries are defined by relative motion or stereo disparity, to perceive coherence in random dot motion fields, and to recover 3-D structure from motion in Johansson biological motion displays. She finds, for example, a group of patients who have a normal ability to detect and measure the velocity of simple targets and to perceive relative motion, but who cannot recognize the shape of objects whose boundary is defined by relative motion or change in stereo disparity. This suggests that the formation of object boundaries from motion discontinuities is performed separately, or represented in a separate area, from the basic motion measurement computation, and that stereo and motion information may be combined for the analysis of these boundaries.

## The Integration of Multiple Visual Cues

The integration of multiple cues is a relatively new area of vision research that is rapidly becoming a major focus of both computational and experimental work. The results presented at this meeting were largely experimental, motivated loosely by computational issues, as researchers look for some initial hints about integration strategies used by the human visual system.

J. Little, University of British Columbia, Canada, discussed recent developments of the M.I.T. vision machine, which combines algorithms for processing motion, stereo, and color, implemented on the connection machine. One of the goals of this system is to identify physical discontinuities in the scene and classify them according to whether they represent object boundaries, reflectance changes, shadows, and highlights. Little and his colleagues have recently introduced using confidence measures to assess the strength of individual boundaries based on the particular cues from which they were derived. The individual processes use very simple operations such as comparisons, summations, and winner-take-all mechanisms, which are, in principle, biologically feasible. A diagram of the overall structure of the integration stage of this system is shown in Figure 2.

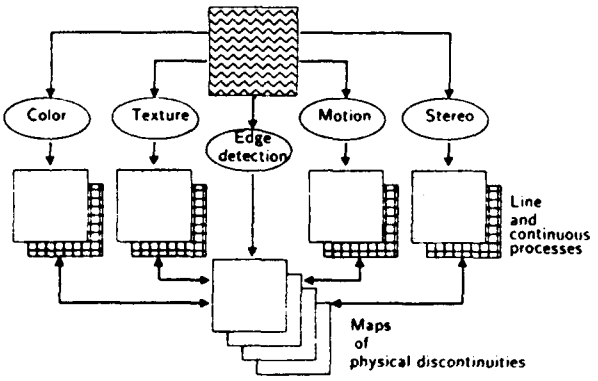



**Figure 2.**

A diagram of the overall structure of the integration stage of the M.I.T. Vision Machine. The outputs of the early visual cues are coupled to line processes that represent discontinuities in visual properties, and continuous processes that represent patches of smoothly varying visual properties. A probabilistic model based on MRFs is used to combine these multiple maps into a final map of the physical discontinuities or edges in a scene. (Reproduced from T. Poggio, E. B. Gamble & J. J. Little, *Parallel Integration of Visual Modules*, Science, vol. 242, 337-484, 1988.) 337-484, 1988.)

Several participants presented perceptual studies that address the computational issues underlying the integration of multiple visual processes. P. Cavanagh's work at Harvard University, Boston, Massachusetts, for example, emphasizes that the interpretation of 3-D shape from 2-D contours is based on contours that can be defined by a wide range of cues. We are all familiar, for example, with the way in which a wire-frame drawing of the edges of a cube, as shown in Figure 3a, or a series of adjacent and parallel curved lines can elicit strong 3-D impressions. Cavanagh has shown that the edges on which these and other 3-D interpretations are based can also be defined by changes in stereo disparity, relative motion, and texture changes as suggested in Figure 3b. Such observations led Cavanagh to propose the model shown in Figure 3c which combines multiple cues to compute common 3-D shape properties.

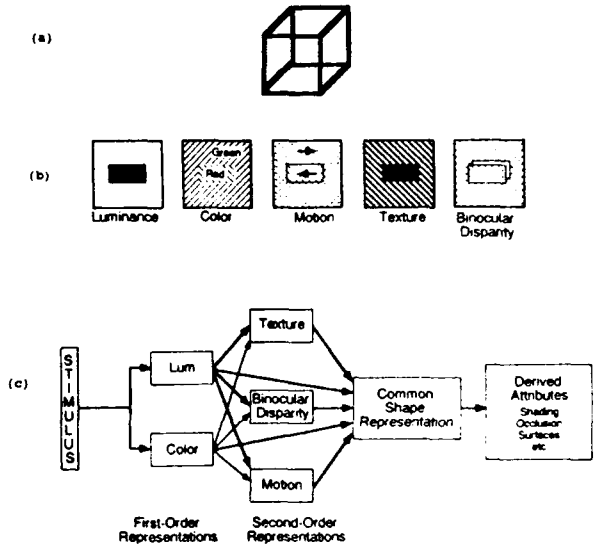



**Figure 3.**

(a) Wire-frame image of a cube, whose edges are defined by changes in luminance. (b) Other visual cues whose discontinuities can yield contours whose structure can indirectly yield an interpretation of 3-D shape. (c) The images defined in the different cues are analyzed in separate representations (modules or pathways) having two levels that correspond to the nature of the surface features that define the cue: first-order, or point features of color and luminance and second-order, or two point features of texture, relative motion and binocular disparity. The discontinuities in the second-order cues emerge from the analysis of shape features at the lower level. The analyses of all the cues contribute to a common representation of stimulus shape from which higher level attributes such as shading, occlusion, and surfaces can be derived.

Psychophysical experiments by B. Rogers, Oxford University, U.K., have explored how depth information from binocular disparity and motion parallax is integrated. Observers viewed simulated 3-D corrugated surfaces whose depth range and spatial frequency is varied, translating back and forth across their line of sight. Depth was specified by stereo disparity, relative motion, or some combination of the two cues, and a matching technique was used to assess the observers' perceived depth. When viewed monocularly with motion parallax as the only depth cue, the depth variations and movement of the surface were perceived almost veridically. If motion parallax is again the only depth cue, but the patterns are viewed binocularly with zero disparity, the perceived depth range is reduced by about half, and the surface appears to rotate as it translates. When correct stereo disparity is combined with the motion parallax cue, perceived depth generally agrees with the stereo cue, as long as the disparity gradients are sufficiently large. When disparity gradients are very shallow, the motion parallax cue can dominate perceived depth. Rogers interpreted these results as suggesting a model in which the visual system finds a solution that minimizes the discrepancy between the interpretations that would result from the stereo and motion cues alone.

H. Bulthoff, Brown University, Providence, Rhode Island, summarized perceptual experiments that he has conducted with Mallot, Blake, et al., exploring the 3-D shape perceived from a combination of stereo disparity, shading, texture gradients, and specularity. These experiments use 3-D ellipsoids of varying shape generated with computer graphics that allows the experimenter to introduce a range of different 3-D cues. Observers specify their perceived depth either with a stereo probe or by matching the perceived shape to one defined by a wire-frame object presented with stereo disparity alone. The experimental results suggest that properties such as texture and shading provide a relatively weak cue to 3-D shape when presented in isolation. When presented together, the visual system perceives better 3-D shape as more cues are added together. The strongest of the depth cues studied was stereo disparity, which yields an almost veridical impression of depth. Data from their earlier experiments combining stereo and shading cues is shown in Figure 4. More recent experiments that also consider texture cues yield similar data.

Bulthoff also summarized some recent experiments addressing the interpretation of surface highlights that are generated by mirror-like reflections from glossy surfaces. Such highlights are rich in geometric information about the shape of the underlying surface.

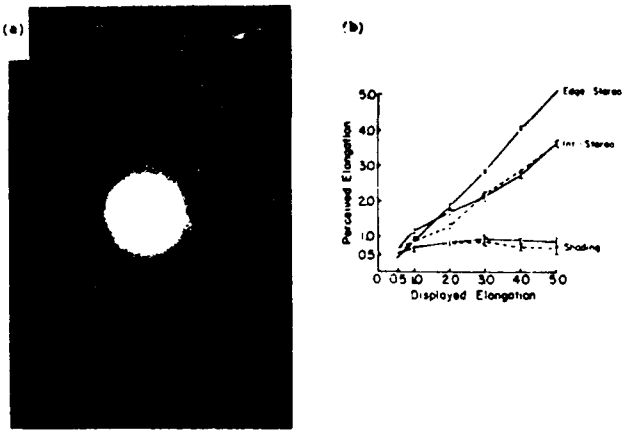



**Figure 4.**

(a) The image of a shaded ellipsoid shape displayed using computer graphics. Such figures were presented to subjects with and without abrupt intensity changes that yield perceivable edges on the surface of the object, and with and without binocular disparity. (b) The perceived elongation of ellipsoids as a function of their true elongation, for the case in which stereo disparity and distinct edges are present (Edge-Stereo), disparity and only smooth shading are present (Int-Stereo) and smooth shading alone is present (Shading). The combination of stereo and edges yields an essentially veridical perception of depth. (Reproduced from H. H. Bulthoff & H. A. Mallot, *Integration of Depth Modules: Stereo and Shading*, J. Opt. Soc. Amer. A, vol. 5, 1749-1758, 1988.)

Experiments were conducted to show that the perception of highlights can influence both an observer's perception of the surface gloss and the perceived curvature of the surface. These observations were interpreted in terms of a physical model of the interaction of light with curved surfaces that may form the basis of the underlying computation of shape from specularity.

J. Frisby, University of Sheffield, U.K., has also explored the integration of depth information from binocular stereo and texture gradients. He found a strong anisotropy in the interaction of these cues, in that perceived depth changed depending on whether the disparity and texture gradients were oriented in the horizontal or vertical directions. (Rogers had also observed an anisotropy in the interpretation of stereo disparity and motion parallax in his displays.) The experiments used both artificial and natural stimuli with surfaces whose shape was planar or contained a parabolic or triangular ridge. The stereo and texture cues were usually placed in conflict with one another. When a planar surface was oriented vertically with different angles of slant relative to the viewer, there was generally some underestimate of the slant of the surface, but the texture cue dominated the stereo disparity cue. When the surface was oriented horizontally, subjects perceived a

surface whose slant was roughly an average of the slants defined by the texture and stereo cues alone. For the case of a curved surface, there was clearly some integration of the texture and stereo cues, but the stereo cue dominated when the surface was oriented horizontally. These experiments suggest a complex interaction between stereo and texture processing that is anisotropic and dependent on surface curvature.

The notion that surface curvature plays a strong role in the integration of multiple shape cues was also explored by K. Stevens, University of Oregon, Eugene. His displays placed stereo disparity in conflict with monocular 3-D cues such as texture gradients and contour shape. He found that for the case of planar surfaces, the monocular cues generally dominated the subjects' percept of surface orientation. Adding linear gradients in stereo disparity had little influence on observers' judgments. When such linear disparity gradients are presented in isolation, subjects perceive a slanted surface, but when presented in conflict with other 3-D cues, the other cues appear to dominate. (Note that this differs somewhat from Frisby's observations.) Stereo cues dominated only in cases where the surface was highly curved or contained a discontinuity in depth. These experimental results led Stevens to postulate that the formation of a surface percept may begin with the construction of symbolic feature descriptors within separate visual processes, which capture properties like local surface curvature, followed by an integration process that compares and pastes together assertions derived from the various individual processes. This integration process is assumed to give preference to cues indicating the presence of more highly curved surface features.

M. Livingstone and D. Hubel, Harvard University, summarized extensive psychophysical and physiological observations that support a distinction between the functional processing that takes place in the visual pathways that arise from the magnocellular and parvocellular layers of the lateral geniculate nucleus of primates. They argue that the magnocellular pathway is essentially blind to stimuli that are presented at isoluminance, meaning that spatial and temporal variations in the stimuli are conveyed only through changes in wavelength (color) with no associated changes in contrast. Many basic visual abilities, such as stereo processing and the recovery of 3-D structure from motion, disappear when stimuli are presented under isoluminant conditions. Livingstone and Hubel use these observations to suggest that the analysis of these cues is therefore based on processing that takes place along the visual pathway that originates within the magnocellular system. The parvocellular system is highly sensitive to color, as suggested by an extensive set of physiological studies summarized by Hubel. The studies support the hypothesis that processing within the parvocellular system forms the basis for computations underlying the analysis of properties such as color and spatial form.

In an effort that uses an observation regarding biological vision to extend current imaging technology, Sandini, University of Genoa, discussed constructing and using a charge-coupled-device (CCD) sensor whose distribution of photoelements is space-variant, similar to the human eye, with spatial resolution decreasing with distance from the center of the sensor. He first discussed theoretical aspects of the space-variant representation and showed several examples of images derived with this new sensor. Then he addressed the computational advantages that can be obtained with such a sensor for a wide range of problems including measurement of motion, use of motion processing for navigation, rapid selection of salient image locations for more detailed processing, and object recognition. Although not directly addressing the integration of multiple visual cues, this work highlights an important property of the visual system that may impact a wide range of visual processes in similar ways.

## Higher-Level Visual Processing

With regard to higher-level aspects of visual processing, the presentations focused on three closely related problems.

1. Salient image feature selection for tasks such as recognition
2. Visual attention, including both selecting features as a new focus of attention, as well as mechanisms underlying the physical shift of attention from one location to another
3. Object recognition.

Again, researchers considered a combination of computational models, perceptual observations, and physiological experiments in these areas.

G. Berlucchi, University of Verona, Italy, presented the results of psychophysical experiments that shed light on the mechanisms that underlie involuntary shifts of visual attention. Previously, it was known that the time required for an observer to recognize an object in the visual field decreases if the person is primed about the location at which the object will appear. Early experimental results are consistent with an attentional mechanism that has a limited spatial field that can be shifted across the visual field in time that is proportional to distance. Berlucchi's experiments measured reaction times for detecting a spot of light presented in different locations of the visual field. First, he probed the spatial extent of the so-called spotlight of attention by exploring the dependence of reaction time on the distance between the priming stimulus and test stimulus. Second, he

examined the temporal properties associated with changing the direction of motion of the spotlight of attention. He found a significant increase in reaction times when the observer had to change the direction of motion of the attentional mechanism, even when the priming stimulus was very close to the test stimulus. Berlucchi interpreted this observation in terms of a coupling of the attentional shift with mechanisms underlying the anticipation of a motor reaction. In addition, he attributed the long time associated with changes in direction to the time required to change the state of the motor system.

R. Watt, University of Stirling, Scotland, argued that attentional mechanisms may already operate at a very early stage of visual processing. Also, he attempted to account for some attentional phenomena in terms of the behavior of early processing mechanisms. This work was motivated largely by a computational model of the early processing stages in human vision developed by Watt and M. Morgan, University of Edinburgh, Scotland. The model, called MIRAGE, extracts symbolic edge features from the interaction of multiple spatial frequency filters applied to the retinal image. A difficult computational problem addressed in this work is how to choose an appropriate spatial scale for the analysis of relevant image features. At finer filtering scales, many intensity changes may be caused by noise or insignificant texture in the image. At coarser scales, spurious intensity edges can often result from the smoothing together of nearby edge features. Watt's perceptual experiments suggest that attentional mechanisms, possibly driven by the particular visual tasks to be performed, may play a role in selecting the scale at which image features emerge in the final percept of a visual pattern.

In recent developments of their MIRAGE system, Watt and Morgan have used the centroid of salient visual patches to compute location information for tasks such as object recognition and manipulation. Morgan presented the results of perceptual experiments that support using the centroid for tasks such as judging the metric distance between two objects or parts of objects. His results suggest that the visual system is, in fact, not capable of judging the distance between arbitrary small features in a natural visual scene, and uses more area-based positional information. He discussed designing an algorithm to perform a centroid-like computation as well as possible neural mechanisms that could underlie this computation.

C. Morrone, University of Pisa, Italy, also addressed the analysis of salient image features by the human visual system, and presented both the results of psychophysical experiments and a computer algorithm that address this analysis. D. Burr, University of Pisa, Italy, and Morrone, developed the algorithm that begins with the output of a set of spatial frequency filters tuned to different frequency ranges that are split into odd and even parts. The algorithm produces a representation of the significant intensity edges in an image that successfully captures much of the information in natural images that human observers would subjectively judge as being important. This is accomplished by using simple operations such as summation and squaring of individual filter results and summation across scales. Morrone presented psychophysical experiments with artificial visual stimuli that support the processing steps used in this computational model.

The study of the role of visual attention has recently become an active focus of physiological investigations. J. Maunsell, University of Rochester, New York, summarized a series of experiments that he has conducted on the behavior of neurons in area V4 of primate visual cortex (site of form analysis). They show modulation of the responses of these neurons by the attentional state of the animal. In particular, neurons are found that will respond to a particular visual property, such as stimulus orientation, only when the animal is performing an active task involving using this information. Some neurons are multimodal in that they combine information derived from visual or tactile stimulation. Some neurons also show activity that is coupled to the memory of particular information, again exhibiting a role of attention.

S. Ullman, M.I.T., addressed computational models of object recognition, focusing on two problems. The first is the selection of appropriate internal 3-D models to match a viewed 2-D object. The second is the extraction of salient image features for performing this matching task. He summarized an alignment method that he has developed for recognizing 3-D objects from 2-D views, which divides the selection process into two stages. The first stage computes the best 3-D transformation between a small set of salient image features and possible corresponding features on the internal object models. The second stage chooses a model that best fits the transformed image features. In discussing this model, Ullman presented a valuable theoretical result that shows that the set of all possible 2-D views of a rigid 3-D object is spanned by a linear combination of only three views of the object. This suggests that a recognition system need only store a few characteristic views of an object to recognize the object in a wide range of 3-D positions and orientations. With regard to selecting salient features, Ullman presented an algorithm to extract salient contours in a cluttered scene, for recognition as well as other visual tasks. The algorithm is implemented by an iterative network that uses simple measures of properties such as the length, contrast, curvature, and color of pieces of edge contours to compute the saliency of individual contours. After a few iterations of the network, image contours that human observers judge as salient emerge as having a larger objective measure of saliency. The

algorithm has been very successful in the analysis of natural cluttered images. An example of the results is shown in Figure 5.

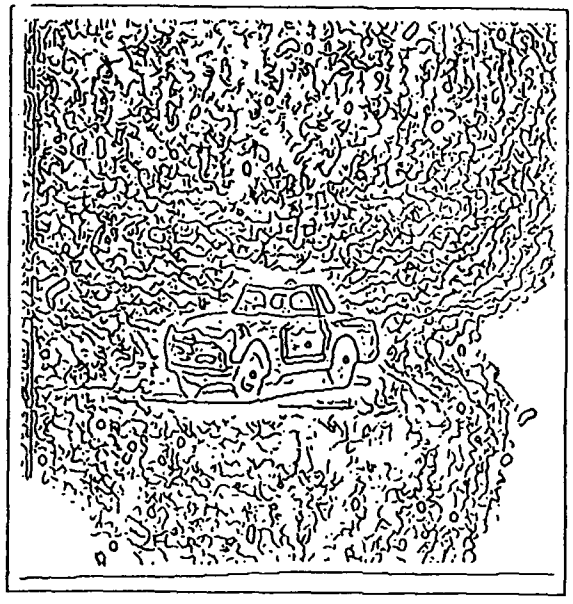



**Figure 5.**

(a) A set of intensity edges computed from a natural image of a car against a cluttered background. These edges were obtained by detecting the zero-crossings of the result of filtering the original image with an operator whose shape is the Laplacian of a Gaussian function. Our attention is drawn immediately to the outline of the car. (b) A saliency map of the edge image obtained by the network proposed by Ullman and Sha'ashua. The brightness of the contours encodes their saliency, determined after 30 iterations of the network. (c) The most salient contours shown in isolation. (Reproduced from S. Ullman & A. Sha'shua, *Structural Saliency: the Detection of Globally Salient Structures Using a Locally Connected Network*, MIT AI Lab Memo 1061, July 1988.)

D. Hoffman, University of California at Irvine, also explored models for shape recognition, addressing the importance of the decomposition of objects and models into salient parts. He argued that such a decomposition is essential to allow the recognition of objects to proceed when only part of an object is in view and to allow the recognition of articulated and nonrigid objects. He advocated using concave discontinuities in object contours, which often correspond to the locations of curvature minima in projected image contours, to define the boundary between object parts. He presented the results of some recent perceptual experiments that support using such features for segmenting objects into natural parts.

Object recognition has recently become an exciting topic of exploration in physiological studies, after the discovery of neurons in inferotemporal cortex of primates that appear to be involved in face recognition. D. Perrett, University of St. Andrews, Scotland, has explored the nature of the representation of visual information that underlies this face recognition. In particular, he has found classes of neurons that respond to characteristic views of the head, such as head-on views and profiles, as well as neurons whose responses appear to be modulated by the direction of gaze of the head being viewed. The ability of these neurons to respond to faces is very robust, in that it is insensitive to manipulations such as changes in size, position, rotation in the image plane, and the nature of the illumination in the scene. In addition, some neurons respond to caricatures of faces. Perrett also summarized some preliminary studies of cells that appear to play a role in the analysis of biological motion; that is, the movements of other animals through the scene.

## General Meeting Accomplishments

In this section, we evaluate the results of the meeting in light of the goals set forth in the introduction and in light of the criteria for evaluation set out by Torre in his opening remarks.

In motion analysis, the recovery of 3-D structure and motion of object surfaces and the movement of the observer will continue to be a major focus of future research. New theoretical frameworks are still emerging, such as those proposed by Koenderink and by Verri and Torre at this meeting. Researchers have only recently begun to develop working algorithms to solve problems in this area. The development of advanced mobile robots is providing a rich application area for testing these algorithms in the context of navigation. The technology for rapid collection and storage of large volumes of natural image motion data for adequate testing of algorithms has also become available only in the last few years. With regard to experimental work, researchers have only recently devised adequate psychophysical paradigms for performing quantitative studies of human subjects' ability to recover 3-D structure and observer motion parameters. Also, there has been a substantial increase in physiological work in areas MT and MST of primate cortex, which both appear to play a significant role in higher stages of motion processing. Although structure-from-motion is a problem that researchers have long considered, it is an area where we can still expect

major new discoveries of a fundamental nature over the next several years.

Research on the problem of motion measurement has advanced much further than research on higher stages of motion processing. As a consequence, we are beginning to see many studies similar to Franceschini's, which build a complete loop from detailed physiological mechanisms, to computational models, to implementations of these models in special-purpose electronic hardware. Although some important issues remain open, such as the role of multiple spatial frequency channels and tracking eye movements and the reliable detection of motion discontinuities, much of the future research in this area will focus on elaborating in greater detail, the computational mechanisms underlying motion measurement in biological systems.

Integration of multiple visual cues has been addressed only recently in the vision community. Past work has focused on individual processes, and it is clear that the development of high-performance, flexible, and general vision systems must rely on deriving information from a range of visual cues, such as stereo, motion, shading, and texture. There has been some computational work in this area, addressing specific problems such as the integration of motion and stereo information. Some general theoretical frameworks have begun to emerge, such as the Markov Random Fields (MRF) formalism considered by Poggio and his colleagues, but it is probably fair to say that our understanding of possible strategies for integrating multiple visual processes is still very primitive. Researchers have therefore turned to the human visual system for possible hints, leading to the focus on perceptual experiments that we saw at this meeting. Unfortunately, no simple picture has yet emerged from this experimental work. These studies place greater demands on technology, as many used advanced computer graphics to create stimuli that combine a wide range of visual cues to 3-D structure, such as binocular disparity, relative motion, shading, texture, specularities, and surface contours.

Recognition is a problem area that has been considered since the earliest work in computer vision and artificial intelligence. Nevertheless, research over the past few years has seen a quantum leap in the performance of automated recognition systems. Current systems are still very far from having the general recognition capability of the human system. They rely almost exclusively on using geometric shape for recognition. They are all model-based in that they have a relatively small number of stored object models that can be recognized in an image. However, the best current recognition systems can perform well at recognizing 2-D objects from 2-D image data, 3-D objects from 3-D data, and can cope with occlusions and partial data in cluttered natural scenes. This is a major advance from the template-based, binary-image recognition systems of a decade ago. Although the performance of current recognition systems is quite impressive, they have not shed substantial light on the computational mechanisms that underlie human recognition. Computational studies have, however, raised important general issues, such as the nature of the representations of object models, which have been addressed through experimental work. Perrett's work, for example, suggests that for the purpose of face recognition, internal models may use a 2-D, viewer-centered representation of characteristic views of faces.

As vision systems acquire a greater range of capabilities, the role of visual attention will become more critical. For example, it will become necessary to direct the locus of detailed visual processing to different regions of the image, depending on the task to be performed. Too much computation is necessary to perform complete analysis and recognition at a high resolution, everywhere in the image. This is part of the motivation for developing algorithms that can extract more salient features in the image, and for developing imaging hardware of the sort Sandini has explored, in which sampling resolution varies across the visual field. Discovery of task-dependent behavior in neurons of higher areas of visual cortex has led to a flurry of activity on the role of the attentional state of an animal on neural behavior. The ability to conduct physiological studies on awake monkeys trained to perform specific tasks has revolutionized work in this area.

From the material presented at this meeting and from our open discussion of the future of this interdisciplinary approach, it is clear that a strong bridge has been built between computational studies and experimental work in perception and psychophysics. It has been exciting to see many scientists who were trained in psychophysics becoming interested in designing and testing computational models. At this meeting, Bulthoff, Frisby, Watt, Morgan, Burr and Morrone, are psychophysicists who have built computer vision systems to test models that they have developed from experimental observations. At the same time, researchers who have come from a more theoretical discipline, such as mathematics, physics, or computer science, have become engaged in conducting perceptual experiments. Examples at this meeting include Koenderink, Blake, Hildreth, Hoffman, Stevens and Ullman. There was a very strong conclusion that the integration of computational and perceptual studies will continue to provide an essential tool for understanding biological vision and developing successful machine vision systems.

At the same time, there was modest frustration expressed with our slow progress in achieving significant breakthroughs from the integration of computational and physiological approaches. This is partially because

computational models often can be implemented in many ways in neural hardware, so cannot provide sufficient constraint on the expected behavior of single neurons. A given neural signal can also yield many possible interpretations at the abstract, computational level. There have been notable scientific contributions and significant successes in combining computational and physiological approaches, such as the work of Movshon and his colleagues at New York University, and the work of Poggio, Torre et al., on the biophysical mechanisms underlying motion detection. Many presentations showed that some consideration of physiological and computational issues together is both prevalent and valuable in vision research. In general, the building of a close bridge from computational models to underlying neural mechanisms has been a difficult, although scientifically exciting, process. Few researchers have sufficient depth in physiology and computation to be engaged actively in both disciplines. Collaborations can be hindered by a communication gap that results from the differences in training and in point of view that exists between these two disciplines. As mentioned above, the growth in the number of interdisciplinary research projects and the increased cross-training of scientists are steps in the right direction in overcoming some of those hurdles. These steps will contribute significantly to our success in completing the scientific and technological bridge between computational models and experimental physiology.

Participants at the Trieste meeting conveyed a strong sense of commitment to the interdisciplinary study of visual processing. It is becoming more clear over time that some combination of theoretical and experimental approaches is essential, both for understanding biological vision systems and for developing computer systems with the capabilities of human vision. As this style of work becomes more mainstream, we see many more academic programs, meetings, funding programs, and journals, emerging to provide support and to foster this approach.

# NEWS, NOTES, AND ABSTRACTS

## The European Environmental Research Organization

by Keith E. Cooksey, the Liaison Scientist for Biochemistry, Microbiology, and Marine Biotechnology in Europe and the Middle East. Dr. Cooksey is on leave from Department of Microbiology, Montana State University, Bozeman, Montana, where he is Professor of Microbiology.

### Rationale

Until recently there has been no European equivalent of the U.S. Environmental Protection Agency (EPA), thus there has been little transnational coordination of environmental research. This is not to imply that little research is being carried out, but the total European effort has been considerably less then that in the U.S.

The problem in Europe is of comparable size however, and is expected to become even larger once what was formerly Eastern Europe is included. This geographic area brings to the union more than an average share of environmental problems! Now a new body, the European Environmental Research Organization (EERO) has been created to promote research and education on this topic. In particular, the organization wishes to emphasize collaborative research between countries and disciplines. The decision to go forward with the creation of this organization was taken in 1987, but only recently has much progress been made. The initial idea was to create an environmental clone of the European Molecular Biology Organization; i.e., an agency involved directly in research, education, and with its own showplace laboratory.

The creators of the organization are well aware that although chemical and physical process are important in the elimination of toxic materials from the environment, it is microbes that play the major role. Most of the officers of the council are microbiologically trained so that this thinking is to be expected. They also recognize the interdisciplinary nature of the research that is required to solve pollution problems and that this research, just like the problems, should be transnational. A second focus of this organization will be on the means by which production of unwanted toxic chemicals can be reduced or even prevented; i.e., an attempt to tackle the problem at the source.

### Objectives of the European Environmental Research Organization

The objectives are to promote research, stimulate collaborative technology transfers, and provide training in environmental research. To achieve these objectives, EERO will stage workshops and courses at EERO training centers. They will also develop an assessment unit and a showcase laboratory. The laboratory is supposed to undertake research too ambitious for individual European countries. It is hard to envisage a problem so large that it could not be undertaken individually in one or more of the European Community (EC) states, so this has to been perceived as a political means of sharing the research and the resources. This organization expects also to be in a position to promote the exploitation of its research findings as well as advise regulatory agencies.

### Fields of Research to be Promoted

Many of the fields of research to be promoted are those that one would expect; i.e., analytical methods, fate, transport, ecosystem effects, and application of laboratory results to the design of reactors to treat material from contaminated environments. Less obvious is the use of biodegradation studies to formulate the ground rules for designing compounds that are easily degradable. The idea is to find compounds that are useful commercially yet degrade rather easily. In this type of work, it will be important to weigh both properties of the molecule. The organizers note that historically some environmental research has been less rigorously carried out and that probably this has been responsible for the less-than-enthusiastic support of this type of science by the general public. The organizers are therefore concerned that the research promoted by EERO be of the highest quality and relevance.

### Time Scale and Programs

The first 5-year phase will end in 1993. During this time, postdoctoral and short-term fellowship programs will be started. Essentially, these are designed to raise the general level of knowledge throughout Europe and Israel. I find it significant that Israel has been included. Represented on the council are The Netherlands (2), United Kingdom (2), the Federal Republic of Germany (1), Switzerland (1), Belgium (1), Spain (1), Sweden (1), and Italy (1).

The short-term fellowship program is similar in concept to the Office of Naval Research European Office (ONREUR) Visiting Investigator Program; i.e., a short-term visit of 1 week to 3 months. Further development will include setting up regional training centers in laboratories that have special expertise. Again, information dissemination will be enhanced by the publication of laboratory manual. Although the EERO is not an EC organization, I believe it will be quite influential in addressing the EC concerning disparities in environmental regulations between the member states. To this general end, an assessment unit will be established that will monitor all regulatory aspects of the environment. The establishment of the European Laboratory of the Environmental Research in Wageningen, the Netherlands, must be regarded as a significant step in reaching the goals of this organization. Although the Director, Professor Alexander Zehnder, can be reached at the Department of Microbiology of the Agricultural University, the EERO office is off campus.

**Funding**

The goal for the initial years was ECU 2.5 millions per year; however, this has not been achieved yet. Some of the funds came from the Volkswagen Foundation (VW). I have been informed that some countries who are associated with the organization have yet to pay their "dues." About half of the projected budget has been collected so far, but this has not prevented a start on the programs.

**Potential for Collaborative Endeavors**

Professor Knowles, who provided much of the information for this article, thinks that there is room for collaborative efforts between U.S. scientists and members of the individual laboratories even though the organization does not extend officially to the U.S. The laboratories of the members of the EERO Council are all well known as centers of excellence in microbiological research at the biochemical level. Professor Knowles is an authority on cyanide metabolism and the use of planned mixed microbial cultures to remediate toxic materials. He is a member of the Board of Directors and one of the driving forces behind Viridian Bioprocessing--a new company on an industrial park in Canterbury. The University of Kent is also a member of the board so that university research can be exploited by the company without problems of conflict of interest.

Further information can be obtained from the Secretary of EERO, Professor Christopher Knowles, The Biological Laboratory, University of Kent, Canterbury, Kent CT2 7NJ, U.K., or EERO, General Foulkesweg 70, 6703 BW Wageningen, Olanda, the Netherlands.

## 1991 Calendar of Major Events in High Performance Computing in Europe

compiled by Miroslaw Malek, the Liaison Scientist for Computer Science and Computer Engineering in the Office of Naval at Research European Office. He is on leave from the University of Texas at Austin, where he holds the Bettie Margaret Smith Professorship in Engineering in the Department of Electrical and Computer Engineering.

**The Second European Distributed Memory Computing Conference (EDMCC2), Technische Universität, Munich, Federal Republic of Germany, April 22-24, 1991**

Already concluded as this issue is published, the EDMCC2 offered a forum for all users and developers of distributed memory computers. The main focus of EDMCC2 was on methods and tools for the efficient use of such architectures ranging from specification, verification in the early design phases to automatic load balancing, or accounting systems as runtime evaluation support. Especially welcome were reports on experiences with real-world applications and their parallelization using various development tools. Specific topics scheduled to be presented and discussed were:

- Specification, design, runtime, and evaluation tools for distributed memory computers
- Operating systems for distributed memory computers
- Programming languages and compilers for distributed memory computers
- Applications and algorithms for distributed memory computers
- Architectures and technologies for distributed memory computers
- Shared virtual memory
- Interconnection networks.

The EDMCC2 was to include an exhibition of distributed memory computers.

For information, contact:

Prof. Dr. A. Bode
EDMCC2
Lehrstuhl fur Rechnertechnik und
Rechnerorganisation
Institut fur Informatik
Technische Universitat Munich
Postfach 20 24 20
W-800 Munich 2, FRG
Tel: +49 89 21 05 82 40
Telex: tumue d 06-22854
FAX: +49 89 2 80 05 20
e-mail: bode@infovax.informatik.tu-muenchen.dbp.de

**Parallel CFD[1]'91, First Parallel Computational Fluid Dynamics Conference,** Stuttgart, Federal Republic of Germany, June 10-12, 1991

This conference focuses on all aspects of parallel CFD computations. Experience with parallel computers for solving CFD problems is of special interest to meeting participants.

For information, contact:

Dr. W. Schmidt
Messerschmidt Bölkow Blohm GmbH
Leiter des Ressorts Entwicklung
Flugzeugtechnik
Postfach 80 11 60
D-8000 München 80
Tel: +49 89 60 72 02 30

**PARLE '91, Conference on Parallel Architectures and Languages Europe,** Veldhoven, the Netherlands, June 10-13, 1991

This meeting provides a forum for researchers in theory, design and application of parallel computer systems. Specific sessions will feature: cache and memory organizations, parallel architectures, concurrency and semantics, distributed algorithms, garbage collection, mappings to parallel systems, systolic algorithm design, parallel languages, process and net theory, parallel programming, parallel complexity, parallel logic systems, novel neural and optical architectures, dataflow systems, methodologies and toolkits.

For information contact:

F. Stoots,
Philips Research Lab.
P.O. Box 80,000, 5600
Eindhoven, the Netherlands
FAX: +31 40 744758
e-mail:stoots@dooma.prl.philips.nl

**1991 ACM International Conference on Supercomputing,** Cologne, Federal Republic of Germany, June 17-21, 1991

The fifth International Conference on Supercomputing will focus on new research results in the development and use of supercomputer systems. Contributions will emphasize the novel aspects of the work being reported and discuss their implications for future supercomputer development. Papers will cover topics in the following areas:

- Architectural design of supercomputer systems
- Software systems support for supercomputing (parallel languages, compilers, and data dependence analysis)
- Applications of supercomputing
- Supercomputing algorithms and performance analysis
- Scheduling.

For information, contact:

Ruediger Esser
KFA-ZAM
W-5170 Juelich, Federal Republic of Germany
Phone: +49 2461 61 6588
FAX: +49 2461 61 6656
e-mail: zdv003@djukfa11.bitnet

**Transputer Applications '91**

The Third International Conference on Applications of Transputers, Glasgow, Scotland, August 28-30, 1991

Transputer Applications '91 is the third in a series of International Conferences sponsored by the SERC/DTI Transputer Initiative. The conferences are widely acclaimed as highly successful international events. The accompanying exhibitions are increasingly seen as curtain raisers for new products, systems, and tools.

Transputers Applications '91 offers a unique platform to application developers from industry, government, and academia for the presentation of results and experiences arising from the use of transputer-based systems. This conference represents an important forum for the review of progress in this rapidly growing field, and for the identification of current trends and future directions. The conference program will include keynote presentations by leading experts and will span several parallel sessions of contributed papers. Papers may be presented in either oral or poster form.

To reflect the applications flavor of the conference, submissions are invited from the following nonexclusive list of topics:

- Real-time control
- Industrial and commercial applications
- Image processing and pattern analysis
- Software tools and programming environments
- Signal processing
- Standards
- Computational fluid dynamics
- Molecular modeling
- Applications in communications
- Application on proprietary operational systems.

For information, contact:

TA 91 Conference Abstracts
Scottish Transputer Centre
Exchange House
229 George Street
Glasgow G1 1RX
Scotland, U.K.

[1]Computational fluid dynamics

**International Conference on Applications-Specific Array Processors**, Barcelona, Spain, September 2-4, 1991

The aim of this conference is to bring together researchers from throughout the world who work in all aspects of applications-specific parallel architectures from theory to applications and implementations.

This conference is the 5th of the series which began with the First International Workshop on Systolic Arrays held in Oxford, England, in 1986. The series continued in San Diego, California in 1988; Killarney, Ireland, 1989; and Princeton University, Princeton, New Jersey, in 1990. The scope has been expanded since 1990 to reflect the growing interest in applications-specific computing systems. The technical program includes: keynote address, contributed papers, poster presentations, and panel discussion. The themes emphasized include applications, algorithms, software, architectures, design methods, and performance evaluation of applications-specific parallel computing systems.

Papers are expected to address both theoretical and practical aspects of such systems and demonstrate major performance gains. Examples of applications of interest are the processing of image, video and speech signals, communications, neural networks, scientific computing, artificial intelligence, data processing, and manufacturing.

The topics of particular interest include, but are not limited to, the following aspects related to applications-specific parallel processing systems:

| | |
|---|---|
| Applications | Software systems and languages |
| Algorithms | Hardware/Software integration |
| Building blocks | Use of general purpose modules |
| Design methods&tools | Models and evaluation methods |
| Fault tolerance | Technology and VLSI/WSI implementation |
| Optimal designs | Commercial and experimental systems |
| Novel architectures | Design/Specification/Evaluation frameworks |

For information, contact:

Tomas Lang
Dep. de Arquitectura de Computadores
Faculdad de Informatica
Pau Gargallo 5
08028 Barcelona, Spain

or

Jill Comer (ASAP-91)
School of Electrical Engineering
Purdue University
West Lafayette, Indiana 47907

**Parallel Computing '91**, London, U.K., September 3-6, 1991

The aim of the conference is to give an overview of the state of the art of the development, application, and future trends in parallel computing. The emphasis of the conference will be on applications of parallel computing.

Original contributions will be considered for the following sections:

- Numerical and nonnumerical algorithms for all types of parallel computers, including vector and array processors, distributed systems, data flow machines, hypercube systems, cellular/systolic architectures, and neural nets
- All aspects of the applications of parallel computers, including business, industrial, scientific, and engineering applications
- Software for all types of parallel computers, software engineering, programming paradigms, programming languages, programming environments, user interfaces, and system software
- Taxonomy, models and architectural trends of parallel processing; general architecture concepts, simulation, and enabling technologies
- Performance prediction, benchmarking, measurement, and analysis.

For information, contact:

Prof. Dr. David J. Evans
Parallel Algorithms Research Centre
University of Technology
Loughborough LE11 3TU
U.K.

**10th IFAC[2] Workshop on Distributed Computer Control Systems**, Hotel Panhans, Semmering, Austria, September 9-11, 1991

The workshop consists of formal presentations of contributed papers, followed by question and answer sessions and informal open discussion meetings. The topics and subjects will be, but are not restricted to:

- Role of real-time in DCCS specifications
- Designing software with predictable execution times databases
- Real-time communication system architecture including MAP and Fieldbus
- Testing and timing properties of DCCS
- Dependability issues of DCCS
- Current and future impact of novel computer architectures on DCCS
- Insights gained from existing DCCS.

[2]IFAC - International Federation for Automatic Control

For information, contact:

Oesterreichisches Produktivitaets und
Wirtschaftlichkeits Zentrum (OEPWZ)
Rockhgasse 6
1014 Wien
Austria

**2nd Symposium on High-Performance Computing,** Corum, Congress Center, Montpellier, France, October 7-9, 1991

This is the second in a series of biennial symposia. The goal is an overview of innovations in the high-performance computing field. During the last decade, intensive computing (parallelism, vectorization, and scalar processing) has drawn a large audience of engineers and researchers, particularly in classical computations. This has opened several new perspectives which were either impossible to realize or conceptualize previously. To summarize, the main purpose of this meeting is to bring scientists of various fields together to interactively investigate areas such as supercomputer architectures, compilers, algorithms, computational methods, and numerical application.

Architectures and parallel algorithms:

- MIMD & SIMD machines
- Distributed or shared memory
- Communications between processors/memories
- Matching architecture/algorithm
- Massive parallelism
- Industrial accomplishments and theoretical perspectives.

Tools and numerical methods oriented or adapted to parallel/vector computations:

- Compilers and autotasking
- Programming environments
- Data analysis, linear algebraic solvers
- Finite differences-elements-volumes
- Subdomains, spectral, multigrid, Monte-Carlo.

Applications on supercomputers:

- Fluid mechanics, combustion
- Structure and material research
- Wave propagation, seismology, reservoir modeling
- Physics, chemistry, biosciences
- Astrophysics, oceans, and earth sciences
- Social and economic sciences.

For information, contact:

CNUSC
SHPC Secretariat
950, rue de Saint Priest
BP 7229
34184 Montpellier Cedex 4, France
Phone: +33 67 14 14 14
Fax: +33 67 52 37 63
e-mail: shpc@frnop11.bitnet

## Fault-Tolerance Support in Distributed Systems Workshop

by Fred B. Schneider, Department of Computer Science, Cornell University, Ithaca, New York.

In September 1990, the Association for Computing Machinery (ACM) Special Interest Group in Operating Systems (SIGOPS) Workshop on Fault-Tolerance Support in Distributed Systems was held at the University of Bologna. The workshop provided an opportunity for interactions among researchers in operating systems, fault-tolerant computing, real-time systems, and principles of distributed computing. The meeting was organized by Prof. Ozalp Babaoglu, University of Bologna, Italy, and was attended by approximately 70 scientists from 12 countries. This was the fourth in a series of biennial workshops SIGOPS sponsored by the ACM. Unlike its predecessors, the workshop addressed a subject that is generally not treated in depth by submissions to the Symposium on Operating Systems Principles. Covering new intellectual ground is always exciting, and some illuminating discussions occured.

The workshop consisted of 2 1/2 days of brief presentations interspersed with discussions. A couple of themes recurred in these discussions. The first debate was between (what I call) "replication in time" versus "replication in space." Some researchers believe that running multiple copies of an application is the key to implementing fault tolerance. This group is mostly concerned with system support for "replication in space" such as protocols for atomic broadcast, group membership, and so on. Another group of researchers believe that fail over and retry is the key. These researchers are more concerned with failure-detection mechanisms, implementing transaction semantics, logs, and so on. While neither group is prepared to argue that their approach solves all fault-tolerance problems, each group does believe that their approach is sufficiently general and powerful for use in most problems that arise in general-purpose operating systems and in most real-time systems.

A second recurring theme concerned optimistic versus pessimistic implementation mechanisms. Optimistic implementations were described for operating system components to maintain logs, manage a file system, and coordinate a collection of modules (that communicate using message exchange). The idea of optimistic protocols is not new, but fault-tolerance concerns raise some new wrinkles. The breadth of applications using optimistic protocols is expanding at an impressive rate.

Several talks described implementations of running systems that support fault-tolerance of one sort or another. These projects include efforts at Cornell University; Massachusetts Institute of Technology, Cambridge; Vrije University, Amsterdam, the

Netherlands; Institut National de Recherche en Informatique et an Automatique (INRIA), Rocquencort, France; Rice University, Houston, Texas; University of Newcastle, U.K.; and Automation and Systems Analysis Laboratory (LAAS)-National Center for Scientific Research (CNRS), Toulouse, France. It is too early to compare performance of the various approaches, but progress is being made towards the construction of usable research prototypes. A battle of performance figures will surely happen within the next 5 years. Still the field sorely needs problems to use as benchmarks. Real, implemented applications were also discussed. In at least one case (IBM's air traffic control system), current research efforts (from the "replication in space" school) did influence the approach taken.

A detailed summary of the workshop presentations and discussions will appear in an upcoming issue of Operating Systems Review, the quarterly publication of ACM SIGOPS.

## Advances in Parallel Architectures and Algorithms

by Lawrence Snyder Department of Computer Science and Engineering, University of Washington, Seattle

**Introduction**

The Second Annual Symposium on Parallel Algorithms and Architectures (SPAA) was held July 2-6, 1990, in Aghia Pelagia, Crete. In a sense, SPAA returned to its roots, since it grew out of a conference called the Aegean Workshop on Computing held in Corfu in 1988. The sponsoring organization of SPAA is the ACM through its two subunits, the Special Interest Group on Automata and Computability Theory (SIGACT) and the Special Interest Group on Computer Architecture (SIGArch). Also cooperating is the Institute of Electrical and Electronics Engineers Computer Society, the European Association of Theoretical Computer Science, and the Greek Computer Technology Institute. This latter organization was evident at the conference and all indications are that interesting work is being conducted there. P. Spirakis, University of Patras, hosted the conference.

Attracting more than 140 researchers from around the world, the SPAA has become the premier conference on parallel algorithms and architectures. The most outstanding quality of the conference is that the papers generally include both theoretical and practical components, making it nearly unique in the computing field.

The attendees typically study the dual topics--how to

- Make better parallel computers given the needs of parallel algorithms
- Create better parallel algorithms given the realities of parallel computers.

Most varieties of parallel architectures were considered, including shared- and nonshared-memory multiple instruction-stream, multiple data-stream (MIMD) machines, small-scale MIMD, and single instruction-stream, multiple data-stream (SIMD) architectures. Algorithms range from parallel versions of standard problems; e.g., sorting, searching, and graph analysis programs, to several numerical problems involving Toeplitz systems.

A 12-person program committee, chaired by F. Preparata, University of Illinois, Urbana, reviewed the papers. Copies of Proceedings are available from:

Association of Computing Machinery (ACM)
ACM Order Dept.
P.O. Box 6445
Baltimore, MD 21264
Credit card orders: 1-800-342-6626

**Message Routing**

Routing for communication in parallel computers was perhaps the most thoroughly treated topic, representing at least 9 of the 45 papers. One of the standout papers was by F.T. Leighton, Massachusetts Institute of Technology, Cambridge, on average analysis of routing on meshes. Besides getting tight bounds for uniformly distributed loads, he showed the correctness of a rather nonintuitive routing principle: Messages are routed faster on a mesh if they "prefer the straight ahead path over turning" when possible. This insight is contrary to much of the prevailing wisdom.

In hypercube routing, three papers had special value for fault tolerance. One, by J. Bruck, R. Cypher, and D. Soroker, IBM Almaden, showed powerful techniques for routing where many faulty edges were present. The trick is to embed the bounded degree cube connected cycles (CCC) graph. Another paper, S. Konstantinidou and L. Snyder, gave a new adaptive router, called the Chaos Router, the principle of which is to get fast performance and (probabilistic) livelock freedom by using randomness. This Chaos Router is inherently fault tolerant. Finally, Y. Lyuu, Harvard, Boston, Massachusetts, resolved a conjecture of Rabin on information dispersal.

One other ingenious routing paper, by D. Greenberg and S. Bhatt, Yale University, New Haven, Connecticut, included the idea of getting faster delivery of large messages by breaking them up and sending them concurrently via different paths. The trick, of course, is to make sure they do not collide, slowing everything down.

**Multiplication Twice**

There were two impressive papers on multiplication--a topic one would think had been thoroughly studied. M. Shand, P. Bertin, and J. Vuillemin, Digital Equipment Corporation, Paris research laboratory, presented a paper showing how the multiplication of long integers

could be accelerated. The principal applications are in data encryption. Speedup of a factor of 10 over custom very large-scale integrated (VLSI) chips was illustrated. The trick was an elegant combination of number theory and hardware design. B. Becker and J. Hartmann, Frankfurt and Saarbrucken (respectively), Federal Republic of Germany, considered in their paper how to test hardware multipliers. Remarkably, they were able to reduce the number of test patterns needed to 17 for any size multiplier. Again, this was achieved by a combination of good engineering and good analysis.

**Models of Parallel Computation**

As with 1989 SPAA in Santa Fe, New Mexico, the problem of formulating a suitable theoretical model that removes the synchronous requirement of parallel random access machines (PRAM) attracted considerable attention. N. Nishimura, University of Toronto, outlined several criteria by which competing models might be assessed. R. Cole and O. Zajicek, New York University, followed up their Asynchronous PRAM paper from last year with a few refinements. Finally, J. Aspnes, Carnegie Mellon University, Pittsburgh, Pennsylvania, and M. Herlihy, Digital Research Laboratory, Cambridge, Massachusetts, used an asynchronous PRAM model to develop data structures that would not cause competing processes to wait. The nature of the proper model remains unclear to me. R. Anderson, University of Washington, Seattle, motivated by trying to generate random permutations on a sequent symmetry, performed some deep and fascinating theoretical analysis of how biased (in a probabilistic sense) bus arbitration can be and still permit the generation of good results. The work should motivate a new look at practical bus arbitration.

In an exhaustive study of probabilistic parallel transitive closure algorithms, J. Ullman, Stanford University, Stanford, California, and M. Yannakakis, AT&T Bell Laboratories, Yorktown Heights, New York, showed how to "roll your own" fast algorithm based on the sizes of the various inputs. The three-level decision tree dictates different amounts of sampling and differing processing subroutines.

In the informal discussions surrounding the conference, there was much interest in a European effort (spanning several countries) to build a PRAM shared-memory multiprocessor. Apparently, the design will follow the Fluent approach (invented by A. Ranade, University of California, Berkeley).

## The James Rennell Centre for Ocean Circulation

by LCDR Larry Jendro USN, the Liaison Officer for Oceanography and Environmental Systems at the Office of Naval Research, European Branch. LCDR Jendro is an active duty naval officer from the US Navy's oceanography community, currently assigned to the Office of Naval Research European Office.

**A New Center of Oceanographic Research in the U.K.**

The James Rennell Centre for Ocean Circulation (Centre) was officially opened in Southampton on February 26, 1991. The Centre has been established by the National Environmental Research Council (NERC) in Southampton, U.K., to be a component of the Institute of Oceanographic Sciences Deacon Laboratory (IOSDL). The Centre's purpose over a 10-year lifetime is to support, manage, and participate in the U.K.'s contribution to the World Ocean Circulation Experiment (WOCE). Dr. R.T. Pollard, who leads the Marine Physics Group IOSDL, is the first Director of the Centre.

**Centre Goal**

The U.K.'s goal in WOCE is to carry out strategic research, allowing in the next decade, the climate of the ocean to be predicted. The Centre will act to focus contributions from NERC establishments, higher education institutions, the Meteorological Office, and other governmental laboratories and agencies. The Centre will also provide its own research program which will involve the collection and analysis of data sets, and modeling the ocean.

**Organization**

The Centre's staff of 50 is divided into six scientific groups and supported by an administrative team. A high degree of interaction between these groups is anticipated. This will be facilitated by large open plan work areas and a network of SUN workstations with a common file server.

The Survey Team (Mr. Gwynn Griffiths-leader) will enable frequent oceanographic surveys to acquire data at sea and to process data to high standards both at sea and at the Centre.

The Chemical Tracer Team (Dr. Denise Smythe-Wright-leader) will be concerned with the study of physical ocean processes through the distribution of chemical tracers in the ocean, concentrating on measuring and analyzing oxygen, silicate, phosphate, nitrate, chlorofluorocarbons, and plant pigments.

The Meteorology Team (Dr. Peter Taylor-leader) is developing methods for the improved estimation of fluxes between the atmosphere and ocean, using combinations of measurements and model-generated data.

The Satellite Team (Mr. Trevor Guymer-leader) will develop the capability for generating satellite products from new satellite instruments and use the information to study ocean circulation and processes up to basin scales.

The Physical Modeling team (Dr. Adrian New-leader) is developing the Atlantic Isopycnic Model (AIM). This will be used to examine the coupling between the upper ocean and ocean interior and investigate the role of eddies in general ocean circulation. At the same time, they will be constructing feature models to allow the assimilation of ocean features into ocean forecast models.

The Biological Modeling Team (Dr. Mike Fasham-leader) will be working on models of the upper ocean toward the quantitative prediction of carbon fluxes between the deep ocean and atmosphere.

**Master Plan for Site Development**

The opening of the Centre is an initial step in a planned consolidation of British oceanographic facilities. Colocated at the future Southampton Centre for Deep Sea Oceanography, will be the Institute of Ocean Sciences Deacon Laboratory (currently at Wormley, U.K.) including the new James Rennell Centre, the NERC's Research Vessels Services (currently at Barry, U.K.), the University of Southampton's Departments of Oceanography and Geology, and representative faculty from the Engineering and Applied Science Department. Additionally, it is hoped to establish an adjacent Marine Science and Technology Industrial Park to facilitate links with industry.

For further information, contact

James Rennell Centre for Ocean Circulation
Gamma House
Chilworth Research Park
Chilworth, Southampton SO1 7NS
England
Tel: (0703) 766184

## Notes on a Visit to Dr. Marcell Peuckert, Hoechst Research Laboratories, Frankfurt-am-Main August 23, 1990.

by D.H. Liebenberg, Scientific Officer for Condensed Matter Physics, Physics Division, Office of Naval Research, Washington, DC.

My particular interest in visiting Hoechst and Dr. Marcell Peuckert of their ceramics research group was to learn what progress had been made in the area of high temperature superconductivity since a visit that Dr. A. Clark and I made in February 1988 (see ONRL-Report 8-011-R 8 July 1988). At that time the BiSrCaCuO compound had just been announced by Professor Maeda, Japan, yet it was clear that substantial work was in progress at Hoechst. Dr. Peuckert clarified the situation that Hoechst indeed has a position in this discovery since their work was proceeding independently and their knowledge of the compound structure was already well advanced to what was published by Dr. Maeda. So where are they today? Hoechst is a chemical producer and intends to be a supplier of the basic products to support a variety of devices and wires. Thus, they have on the market a product line of the Bi materials. To support these product lines and to provide research that might lead to new similar products their research involves substantial powder synthesis and solid-state chemistry to look at phase purity, additions or substitutions such as Pb, and to carry out sufficient testing, of critical currents at low total currents, as to verify the product quality. Their sales began in 1989 and in 1990 improved data sheets were provided. Especially noted was the improved chemical purity of the YBCO product and also the phase purity of the Bi(2223) high-temperature phase. The single layer material with Ca doping (2111 phase) has an increased Tc of 70-89 K; the critical current is not yet determined. The double layer material has different grades but can be provided with Tc of 90-92 K, phase pure, and with Jc of 35,000 A/cm$^2$ for B = 0 T and T = 5 K. At this temperature, the Jc is nearly constant to 5 T but above 30 K a rapid decrease occurs in this bulk material. The 35,000 A/cm$^2$ seems to be intrinsic since it is in agreement with independent results of Siemens. For the triple layer material with Pb doping, there is a large anisotropy ratio of 12-15.

A current interest is the development of the CVD process for the YBCO material. They are producing their own precursor material of beta-diketonates and Dr. Peuckert noted again the importance of purity. Films between 0.5- and 1-$\mu$ thick are made with this process and have Tc = 91-92 K and Jc values in excess of $10^5$ A/cm$^2$. The patterning must be further developed before better Jc measurements can be made and the contact resistance must be of increasing concern with the higher Jc values. They have found that the Bean model used with SQUID susceptibility measurements gives good agreement with transport measurements on these films.

Dr. Peuckert was properly pleased with the phase diagram studies that his group has made and which results are vital in developing improved processing procedures - especially for manufacturing. He has been in contact with the U.S. National Institute of Standards and Technology (NIST), Gaithersburg, Maryland, work in this area. These results are soon to be published in the Proceedings of the Garmish-Partenkirchen Conference held in May 1990. I noted that there was little U.S. participation in this conference although the Japanese were very well represented.

Although the visit was somewhat rushed since vacations and preparations for the Applied Superconductivity Conference were in progress Dr. Peuckert gave a useful discussion of the Hoechst activities in the high-temperature superconductors and the information on their CVD film processing suggests we stay tuned.

## Superconductor Research in Russia

by Warren E. Pickett, Complex Systems Theory Branch, Office of Naval Research, Arlington, Virginia.

The 1990 International Seminar on the Theory of High-Temperature Superconductors was held at the Joint Institute of Nuclear Research (JINR), Dubna, Russia, a small town on the banks of the Volga about 120 km north of Moscow. The conference was organized by N.M. Plakida, JINR, and Yu. Kagan, Kurchatov Institute of Physics in Chernogolovka. The conference consisted of about 15 invited speakers from western countries and 15 speakers from eastern countries. Total attendance was approximately 125. The focus was on discussing possible (preferably likely) mechanisms of electron pairing, leading to high-temperature superconductivity.

Recent experimental results on the electron-phonon mechanism indicate intimate connections between the lattice and the superconducting state. At the same time, recent theoretical results indicate a substantial strength of interaction. Several talks were based on strong correlations models, as well as on the anion model, the marginal Fermi liquid picture, and the spin bag and bipolaron models. As might have been anticipated, there was nothing close to consensus at the end.

The atmosphere at this conference and the tenor of my interaction with scientists in general were different on this trip than on any of my previous foreign trips. There was an underlying shared emotion because of the interaction between East and West. The emotional connection was intensified by the realization of the difficulties faced in the near future not only by Soviet scientists but by all the Soviet people. At the conference banquet, Prof. Kagan suggested that Soviet-American joint ventures in business, now encouraged by both governments, need to be expanded rapidly.

I also visited the Superconductivity Theory Group of the Lebedev Institute (Institute) in Moscow where Dr. Igor Mazin was my host. Dr. E. G. Maksimov heads this group. The group is very active in the application of density functional techniques to several properties of high-temperature superconductors, as well as being involved in other aspects of the theory of solids. Since their interests very strongly overlap with mine, it was extremely useful to have 4 days of long discussions on several topics.

Sergey Savrasov (a student in Maksimov's group) has developed a method for calculating directly linear response of the density to perturbations using self consistency (a straightforward numerical process) rather than summation over virtual states (a troublesome, ill-convergent process). Likely we can adapt his procedures to our use. Fortunately, Savrasov and I had long, detailed discussions.

Current regulations allow scientists at the Institute (and many others, I surmise) to spend every 5th year outside the U.S.S.R., assuming proper invitation and the necessary financial support is available. The Institute provides some support, but I think it is minor. In addition, they can spend 3 months outside the U.S.S.R. in each of the intervening 4 years. There are strong attempts to make the scientific climate attractive enough that scientists who interact outside will want to return. Considering the present economic uncertainty, it will take some time to achieve this goal. There are, however, scientists (such as Maksimov, for example) who travel outside the U.S.S.R. frequently but whose primary goal is to continue to lead an active group at home.

Some institutes are hard hit by scientists leaving to collaborate in the West or to emigrate. At the Institute, there are enough senior people abroad that the extra load is clearly felt by the remaining staff. The Superconductivity Theory Group is not allotted enough space for everyone to work at the same time. Theoreticians often work at home for a couple of days a week. However, it is mandatory to attend at least two weekly seminars.

## Hungary--National Academy of Sciences and National Committee for Technological Development

by Tom Owens, National Science Foundation European representative.

### Introduction

The National Science Foundation (NSF) is interested in the science policy of Hungary and in the new Regional Environmental Center (REC). To gather specific information, I traveled to Hungary and met with the Director-General of the Hungarian Academy of Sciences and the President of the National Committee for Technological Development for a review of current issues in Hungarian science policy. In addition, I met with the Executive Secretary of the Environment Center and his staff about possible cooperation between the NSF and the REC. The opinions expressed, except where otherwise noted, are those of the people I visited (as I understood them).

**National Academy of Sciences Policy Development**

Dr. Istvan Lang is the Director-General of the Hungarian Academy of Sciences. He started the discussion with the caveat that the government that came to power in April 1990 has said that science and technology (S&T) are not critical issues. Until after 1991, privatization, inflation, and establishing a European Community-oriented (EC) foreign policy will use much government energy and resources. The result for S&T will be generally flat budgets in real terms. For this period of crisis management, the S&T function is under a minister without portfolio. The Prime Minister has a Science and Technology Council (S&T Council) that includes the Minister of Education, the Minister of Finance, the President of the Academy of Sciences, and the President of the National Committee for Technological Development. Soon, the S&T Council will be receiving suggestions for government programs from a planned Science Policy Council. On this council will be scientists and representatives of the ministries on the S&T Council. The deliberations of both councils will contribute to the S&T part of a government working program of targets/aims (not a plan).

The National Committee for Technological Development (NCTD--sometimes referred to as the National Board for Technological Development) is a government body similar to the State Committee for Technological Development in the Soviet Union. Work is concerned with the support of applied research and development. The NCTD is also charged with developing cooperation with the EC--how to get Hungary into EC research programs. Hungary has requested associated partner/member status; further development of the EC relationship will take time. The NCTD is currently trying to implementing Western aid programs, including PHAR and TEMPUS, administered by the EC.

**Functions of the National Academy of Sciences**

The National Academy of Sciences (NAS) performs the classic advisory functions of academies elsewhere, performs research through its 39 research institutes, and makes grants for research to scientists and engineers at any research establishment in Hungary. The Secretary-General chairs the grants committee. The NAS will increase its advisory function in the new government, especially once the government moves from the crisis-management style of operations. The NAS's research institutions will get more independence over time. With staff advice, directors of the institutes are appointed by the President of the NAS. In 1990, there were 4 new directors elected and appointed, and an additional 22 are scheduled for replacement in 1991. Institutes are free to leave the NAC and go their own way or to affiliate with a university. Budget and equipment at the NAS institutes are better than at the universities. Over time, however, the movement to independence may increase substantially, with some NAS institutes forming national centers.

From 1991, the National Technical Research Fund from which research grants are made will be legally independent. A small organization will be formed to administer the grants. The NAS will surely be called upon to participate in the peer review of proposals. Final decisions on the disposition of the approximately 1 billion Forint, however, will be made by the three disciplinary collegiums of the new organization. Also in 1991, the NAS will seek a new law giving it full autonomy (with a subvention from the national budget). In the new incarnation, the NAS could also receive money from the National Committee for Technological Development and from industry via contracts for research services.

**International Cooperation**

Hungary should have a wide range of S&T contacts. While Hungarian postwar relationships were focused on the socialist countries, there have been changes over the past 20 years, and scientific cooperation has been broadened. Today, the plan is to promote cooperation with a variety of countries in Europe, including the U.K., the Federal Republic of Germany (FRG), France, Italy, the Scandinavian countries, Austria, Switzerland, and Spain. Outside Europe, they will continue to develop their relationships with the U.S., Canada, and Japan. Overall, the U.S. and the FRG are the two countries with which Hungary is most likely to pursue cooperative links in S&T. Cooperation with France is well developed in the social sciences and the humanities, and there is a cooperative agreement with the Centre National de la Recherche Scientifique. There will probably not be as much cooperation with France as with the U.S. or the FRG. There has not been a dramatic increase in France/Hungary contacts since the French announced their program of support for Eastern Europe.

Cooperation with the U.S. is generally going very well. There are some problems with the academy-to-academy exchanges. The primary problem is low per diem rates in Hungary. Though the Hungarian side has agreed to raise the per diem for American researchers to 800 Forint per day, that is still considered low by many Americans. The NAS has suggested that the number of visits be curtailed.

Hungary has always been a willing supporter of the International Institute for Applied Systems Analysis (IIASA), primarily because it is an excellent place for East/West cooperation. The IIASA is not so unique today but it probably has a role for the rest of this century. The key question is what should the focus of new problems be when there are plenty of venues for examination of East/West problems? Possible focus areas are global environment, economics, and development (including changing economic structures in

Europe and elsewhere). In any event, Hungarian scientists support IIASA so participation for the time being will be continued. An orientation toward strong projects within a program that can be given 3-year funding will likely be the most productive.

There is a continuing possibility for brain drain from Hungary as researchers use their ability to travel freely. To a certain extent, this is to be expected. There are 3,000 researchers in the NAS institutes, and 15 percent are working abroad; 3 years ago, it was 10 percent. These researchers are now distributed about equally in the U.S., the FRG, and the rest of the world. Probably about two-thirds will return some day. Today in Hungary, one can find many scientists who left after 1956 and later returned to help build Hungarian science.

**National Committee for Technological Development**

Dr. E. Pungor is the President of the National Committee for Technological Development (OMFB), successor to the State Office for Technical Development. Over the next year or two, it will be necessary to change the way government-supported applied research is carried out. The government budget that supports applied research is about 11 billion Forint. This amount is currently distributed to research institutes of various ministries through those ministries. In the future, the NCTD will distribute this money via competitive awards. To accomplish the changeover will involve some adjustments. Institutes that are not competitive will have some trouble getting funds that they used to receive routinely.

The current distribution of funds for applied research is about 20 percent for museums and related institutional support, 20 percent for innovative research projects on themes suggested by the researchers, and 60 percent for government priorities. These proportions will generally be kept under the new system administered by the OMEB. The various ministries will establish their priority research areas but the research to address the priorities will be selected on merit rather than on institutional affiliation. Transferring the results of this research to the economy will be a very high priority. Accomplishing the transfer will be complicated and made much more difficult by the lack of trained Hungarian managers. The EC programs for research support are going to be important for Hungary, and some (like TEMPUS) are already having an effect in Hungarian universities. Hungary is participating in the activities of the Italian initiative "Pentagonalla" which is a venue for cooperation between Italy, Austria, Yugoslavia, Hungary, and Czechoslovakia.

The possibility of a brain-drain of Hungarian researchers is real. However, one cannot have a policy of freedom of movement unless people are free to move. Some will go; most will not. In the end, some of those who go will come back well trained. There are more serious problems that must be dealt with now.

**The Regional Environmental Center**

Mr. Peter Hardi is Executive Director of the REC. His job is to develop the REC's mission--to facilitate documentation and dissemination of data on environmental problems in the region, and to educate and promote public awareness of environmental issues and problems. In addition, the REC will be a clearinghouse to match programs with needs and organizations in the region. Finally, it will help to strengthen nongovernmental environmental organizations in the region. The REC's work is highly problem oriented.

I raised the question of cooperation between the REC and the NSF on problems of mutual interest. After some discussion, we identified some possibilities. The REC

- Is willing to be a clearinghouse for access to students and postdocs being trained in environment-related disciplines within the region. This could make it possible to mount a joint program by which NSF assists American researchers to bring Eastern European students/postdocs to work temporarily in U.S. laboratories. Joint funding (NSF/REC) of such a program would also be possible. The REC could review proposals for work proposed to NSF to take place in Eastern Europe relevant to the region's environmental problems and issues.
- Is willing to provide a "ground truth" review of the feasibility and potential of proposed research projects in the area, considering the relevant realities--political, institutional, and resources related.
- Can finance participation of local researchers in projects including additions to work that is financed by another organization. Satellite data analysis and environmental systems modeling could be examples.

At this point in our discussion, Mr. Larry Koskinen, REC Project Manager, replaced Mr. Hardi. Mr. Koskinen said that the REC would be linked to the EARN and BITNET networks, and possibly Internet. The REC will be able to accommodate software and experience of visiting researchers in Macintosh, IBM, and DEC formats.

# The SCIENCE Plan of the Commission of the European Community

by Tom Owens

## Introduction

The SCIENCE Plan (Stimulation des Cooperations Internationales et des Exchanges Necessaires aux Chercheurs en Europe) of the Commission of the European Community (Commission) is a program designed to stimulate collaboration and mobility among European researchers. The SCIENCE Plan is a sequel to a previous STIMULATION[1] Plan, which had similar objectives. A SCIENCE Plan objective is to reduce the disparities in science and technological capacity that exist between EC member states. This report is based primarily on a meeting with Mr. Luis Minguez, who manages many of the day-to-day elements of the SCIENCE Plan. Except where otherwise indicated, the views contained herein are those of Mr. Minguez (as I understood him).

## SCIENCE Plan Support Categories

The SCIENCE Plan supports several types of projects in the natural sciences and mathematics. I will discuss two of them: twinning and operations.

Twinning of laboratories in different EC countries is meant to assist the mobility and networking of researchers within the community. Contracts in this category provide for 100 percent of the costs of equipment, computer time, travel, and personnel necessary to carry out a collaboration in research of interest to the participants. Participation is open to industry, university, or government research institutions in the EC countries. Research institutions in the European Free Trade Association (EFTA) may also be included with EC partners. About 60 percent of SCIENCE Plan funds go to twinnings, with the average project involving two to four laboratories with a budget of 200,000-250,000 ECU.

Operations awards support problem-oriented research with a planned specified result. Items that may be supported are the same as twinnings but may cover 50 percent of the full cost of the research rather than just the marginal costs of internationalizing it. New personnel may be hired specifically for the project. About 30 percent of SCIENCE Plan funds goes to operations. The average operations project budget is 500,000-1.5 million ECU.

The remaining 10 percent of SCIENCE Plan resources is for smaller activities aimed at training fellowships for young researchers. Participants can spend 1-2 years at a laboratory in an EC country other than their own (bursaries). Also covered are the costs to laboratories of receiving foreign researchers for 1 to 2-year stays (grants). Possibly, training could be an important element in the future versions of the SCIENCE Plan. (At a recent European Science Foundation Assembly, the EC was said to be considering the possibility of 5,000 postdoctoral fellowships per year to be used in EC countries.)

Proposals to the SCIENCE Plan average around 600 per year with the following approximate divisions: Life Sciences-30 percent, Physics-20 percent, Chemistry-20 percent, Mathematics-10 percent. The rest is divided among several disciplines. There is an imbalance between the number of proposals and the 34-35 million ECU available for funding projects. Only 60 or 70 proposals can be funded this year (success rate of only 10-12 percent). In 1988, the success rate was 24.5 percent; in 1989, it was 17.5 percent.

## The Committee for the European Development of Science and Technology

The Committee for the European Development of Science and Technology (CODEST) acts as an advisory committee for the SCIENCE Plan, and recommends projects to be supported. The CODEST has 25 members from EC countries and 5 from EFTA countries, all eminent members of their respective establishments (see Appendix for CODEST members). The CODEST meets quarterly to deal with SCIENCE Plan matters. The committee makes recommendations with the advice of reviewers (three or four on each project). Reviewers are drawn from the research communities of countries worldwide, not just in Europe. Selection criteria for proposals include (roughly in order of importance) scientific quality, innovation, interdisciplinarity, the level of European collaboration or European character, and some balance among the various fields of research. The review and selection process takes 3 to 4 months from receipt of proposal. Each SCIENCE Plan award is signed by Mr. F. M. Pandolfi, Director-General for Science, Research and Technology.

[1] EUR 12854 - Evaluations of the Science/Stimulation Plans (1983/85, 1985/88, 1988/1992) Luxembourg: Office for Official Publications of the European Communities, July 1990.

The future of the SCIENCE Plan will probably see postdoctoral research fellowships as a major element. This depends on the final outcome the Third Framework Programme review and on the resources allocated to the approved activities. Other priorities will include building networks of centers of excellence and joint projects, which would help to encourage interdiscipliary cooperation, diffuse skills, and encourage projects with both applied and fundamental research in industrial laboratories. Since there is some overlap between the Second and Third Framework Programmes, there may be more resources available for the SCIENCE Plan over the next few years than originally planned.

A July 1990 evaluation of the SCIENCE Plan and its predecessor STIMULATION concluded that similarities existed between this EC activity and the NATO scientific program. The review committee suggested that it might be advisable to explore possibilities for new relations with NATO and with Eastern Europe in the context of the SCIENCE Plan. The review showed that France, the U.K., and the Federal Republic of Germany (FRG) were the sites for most of the laboratories successful in obtaining contracts between 1985 and 1989. During the same period, the contracts were concentrated in Physics and the Life Sciences with strong representation of Chemistry and the Earth Sciences. The evaluation recommended a role for the SCIENCE Plan in the broadening of experience which comes during the postdoctoral years (which "is dominated by the U.S.") and some large multinational projects, and a moving-away from smaller projects by establishing a minimum-sized proposal amount.

This program is one in which various approaches have been tried for networking, training, and promoting cooperation between private, governmental, and educational research institutions in Europe. New emphases and perhaps other new approaches will be tried out, possibly with greatly increased resources. If the new proposals become reality, the potential impact on the decisions of European postdocs who are considering a stay in the U.S. or Europe will be as great as anything so far devised by the EC. However, it is likely that only the continued strength of the science and engineering being conducted in U.S. laboratories will be able to ensure that European postdocs will continue to take part of their training in the U.S.

# Appendix

## CODEST Members

Monsieur Algrain
Conseiller Scientifique
Président du Groupe Thomson
Cedex 67
F-92045 PARIS La Défense
France

Tel: 33/1/49 07 84 90
or 49 07 86 43
Tlx: 042/204 780 TCSF
Fax: 33/1 49 07 83 00

Professor Thor Bak
Royal Danish Academy of Sciences and Letters
Hans Christian Andersen Blvd., 35
DK-1553 - Copenhagen V
Denmark

Tel: 45/33 11 32 40
Tlx: 15 652 fadk
Fax: 45/33 91 07 36

Professor Augusto Barroso
Departemento de Fisica
Universidade de Lisboa
Ed. C1 Piso 4, Campo Grande
1700 Lisboa
Portugal

Tel: 351/1/758 31 41
Tlx: 65869 FCULIS
Fax: 351/1/759 77 16

Professor Giuseppe Biorci
Vice Presidente
Consiglio Nazionale delle Ricerche
*Piazzale Aldo Moro n.7*
I-00185 Roma
Italy

Tel: 39/6/49931
or 493440
Tlx: 610076 CNR RM I
Fax: 39/6/4957241

Professor N. Cabibbo
Presidente INFN
Piazza Dei Caprettari, 70
I-00185 Roma
Italy

Tel: 39/65 47 731
or 49 91 43 49
Tlx: 614125 INFNUP I
Fax: 39/6-65 47 924

Professor U. Colombo
Presidente E.N.E.A.
Viale Regina Margherita 125
I-00198 Roma
Italy

Tel: 39/6-85 10 07
Tlx: 043/610 167 ENEA I
Fax: 39/6-852 858 04

Dr. De Waard
Rijksuniversiteit Groningen
Laboratorium voor Algemene Natuurkunde
Westersingel 34
NL-9718 Groningen
the Netherlands

Tel: 31/50-63 47 37
Tlx: 044/77 391 RUISO
Fax: 31/50-63 34 71

Monsieur C. Fréjacques
Président
Centre National de la Recherche Scientifique
29 Rue Paul-Bert
94200 Ivry-Sur-Seine
France

Tel: 33/1/4960 4059

Fax: 33/1-4670 2810

Dr. M.W. Geerlings
Corporate Director for Research
Akzo N.V.
Velperweg, 76
P.O. Box 9300
NL-Arnhem SB 6800
the Netherlands

Tel: 31/85-66 29 30
Tlx: 45 438
Fax: 31/85-66 33 43

Professor Dr. B. Hess
Vice-President, M.P.G.
M.P.I. für medizinische Forschung
Jahnstrasse 29
D-6900 Heidelberg 1
FRG

Tel: 49/6221-48589
Tlx: 461505 mpimf d
Fax: 49/6221-486340

Professor F.C. Kafatos
Director - Institute of Molecular Biology and Technology
Research Center of Crete
P.O. Box 527
Heraklion 7110 - Crete
Greece

Tel: 30/81-23 97 57
or 23 11 99
Tlx: 0601/262 728 MPUC GR
Fax: 30/81 23 97 35
or 23 88 24

Professor F.C. Kafatos
Biological Laboratories
Harvard University
16 Divinity Ave
Cambridge MA 02138
U.S.

Tel: 1 (617) 495 3266

Monsieur F. Kourilsky
Directeur Général
C.N.R.S.
Quai Anatole France, 15
75700 Paris
France

Tel: 33/1/47 53 14 90
or 47 53 14 75
Tlx: 042/260 034 CNRS F
Fax: 33/1/47 53 00 09

Professor Dr. H. Markl
Präsident der Deutschen Forschungsgemeinschaft
Kennedyallee, 40
D-5300 Bonn 2
FRG

Tel: 49/228-885(1)-2222
Tlx: 17 22 83 12
Fax: 49/228 885 22 21
or 49/228 885 24 25

Professor Pedro Pascual
Secretaria de Estado
Universidades e Investigacion
Serrano, 150
28006 Madrid
Spain

Tel: 34/1-26 15 400
Fax: 34/1-26 25 782

Sir David Phillips
SERC
Polaris House
North Star Avenue
Swindon
SN2 1ET
U.K.

Tel: 44/793-411 036
Tlx: 44 94 66 GTN 1434
Fax: 44/793-411 400

*Professor I. Prigogine*
Campus de la Plaine - U.L.B.
Code Postale 231
Boulevard du Triomphe
B-1060 Brussels
Belgium

Tel: 640 00 15
ext 5540
Tlx: 23 069
Fax: 649 87 74

Professor Galo Ramirez
Centro de Biologia Molecular
Universidad Autonoma de Madrid
Campus de Cantoblanco
28049 Madrid
Spain

Tel: 34/1-3975070
Tlx: 27810 educi e
Fax: 34/1-3974799

Sir Charles Reece
Heath Ridge
Graffham
Petworth
W. Sussex
GU28 0PT
U.K.

Tel: 44/79 862 74
(private)
or contact point for
Tel: 44/1 798 5423
Fax: 44/1/828 2427
or 834 2042

Dr. Pierce Ryan
TEAGASC
Sandymount Avenue 19
Dublin 4
Eire

Tel: 353/1-68 81 68
Tlx: 0500/30 459
Fax: 353/1-688 023

Monsieur M.P. Seck
Centre Universitaire de Luxembourg
Département des Sciences
162a Avenue de la Faïencerie
L-1511 Luxembourg
G.D. Luxembourg

Tel: 352/21 595
Fax: 352/461 990

Professor Dr. E. Seibold
Geologischas Institut der Universität Freiburg
Albertstrasse, 23
D-7800 Freiburg
FRG

Tel: 49/761-203 23 56
Fax: 33/88-37 05 32

Sir Peter Swinnerton-Dyer
Universities Funding Council
Park Crescent 14
London
W1N 4DH
U.K.

Tel: 44/71-636 77 99
Fax: 44/71-631 4227

Professor Dr. Max Syrbe
*Präsident der Fraunhofer Gesellschaft*
Leonrodstr. 54
D-8000 München 19
FRG

Tel: 49/89-12 05 201
Tlx: 521 5382
Fax: 49/89-12 05 317

Professor Van Overstraeten
Interuniversitair
Micro-Elektronica Centrum vzw
Kapeldreef, 75
B-3030 Leuven
Belgium

Tel: 016/28 13 72
Tlx: 26 152
Fax: 016/22 94 00

## LIST OF REPRESENTATIVES OF EFTA COUNTRIES - June 14, 1990

Professor F. Paschke
Technische Universität Wien
Gusshausstrasse, 27-29/359
A-1040 Wien
Austria

Tel: 43/222-58801
ext 3836
Sec. Fr. Dittelbacher
ext 3835
Fax: 43/222-505 26 66

Professor Y. Neuvo
Department of Electrical Engineering
Tampere University of Technology
P.O. Box 527
SF-33101 Tampere
Finland

Tel: 358/31 162 111
Tlx: 22313 ttktr sf
Fax: 358/31 162 913

Professor J.E. Fenstad
Institute of Mathematics
University of Oslo
P.O. Box 1053
Blindern 0316 Oslo 3
Norway

Tel: 47/2-45 58 65
Fax: 47/2-45 43 49

Professor I. Lindqvist
President of the Swedish Royal Academy of Sciences
Kronasvägen 2
S-752 51 Uppsala
Sweden

Fax: 46/830 13 86

Professor M. Ursprung
Chairman of the Board of the Swiss Federal Institute of Technology
ETH-Zentrum
CH-8092 Zürich
Switzerland

Tel: 41/1-256 20 50 / 20 02
Tlx: 816 039 peth ch
Fax: 41/1-251 98 42

# ONREUR REPORTS AND MAS BULLETINS

## Reports

To request reports, indicate the report number on the self-addressed mailer and return it to ONREUR.

**Aerospace**

*European Space Developments and Programs at the 29th Farnborough International Aerospace Exhibition*, by CDR Robert C. Treviño. (91-1-C) This report is based on the 29th Farnborough International Aerospace Exhibition, the largest aerospace event of 1990. This major biennial aerospace event is organized by the Society of British Aerospace Companies and emphasized that the trend is toward more international joint ventures among European space organizations and companies. International space cooperation both in the scientific and commercial areas will continue, but European space autonomy in manned and unmanned programs is the long-term goal.

## MAS Bulletins

The following Military Applications Summary (MAS) Bulletins were published between January 1, 1991 and April 12, 1991. The MAS Bulletin is an account of accomplishments in European naval research, development, and evaluation. Request copies by number from ONREUR.

- 01-91 Bofors Presented at the Bofors Effect Symposium 90
- 02-91 Harwell Tests New Legionella Killer System
- 03-91 Underwater Scaffolding
- 04-91 MAS Bulletin 1990 Annual Index
- 05-91 SEA BAT 6012, An Electronically Scanned Fast Update Sonar

# THE EMBASSIES: TECHNOLOGY ROUNDUP

## Italy

*For further information on Italian items, contact Reno Harnish, Office of Science Counselor, American Embassy, Rome, APO New York 09794-9500*

**Italian-Built Supercomputer**

At a press conference, Professor Nicola Cabibbo, Director of the Italian National Institute of Nuclear Physics (INFN) presented to the Department of Physics of the Rome university "La Sapienza" the APE100, the new Italian-built, high-speed supercomputer. Array processor expandable (APE) can manage 100 gigaflops which means that it is from 3-to-10 times more powerful than existing supercomputers. The APE100 is a 2048-node machine configured as a 16X16X8 lattice. The characteristics of elevated parallelism and connectivity between the processors (forming a cube whose edges interchange information among themselves) allow calculations at a much higher speed than other supercomputers. One of the purposes of APE100 is to evaluate exactly the performance of quantum chromadynamics (QCD) as a theory of hadronic matter and consider the dynamic effects of quark-antiquark pairs. The APE100 uses APSE, an original high-level programming language. Another feature is an excellent debugging facility.

The APE100 is part of a family of parallel computers that was started as an INFN project in 1984 with the construction of the first APE capable of one gigaflop. The APE100 was started in 1988 with an original and very compact architecture. The APE100 is equal the size of four medium-size refrigerators sitting side by side. The supercomputer is equipped with chips entirely designed and manufactured by the INFN researchers, using 1.2-m (SYMB) technology and each containing 150,000 transistors. The APE100 is a modular structure, and its final version will have 256 calculating boards. The APE100 is programmed to perform during April 1991 at 6 gigaflops. Within a year, it will reach its full capacity of 100 gigaflops.

The overall cost of APE100 is 11 billion lire (about $10 million). This figure is less than the cost of similar supercomputers with lower performance. The APE100 is expected to be the basis for the joint European Community (EC) supercomputer project. This project is expected to carry out one thousand billion operations per second. A meeting sponsored by the EC scientific committee will take place soon in Brussels to discuss the project.

**Italian Biotechnology Hampered by Lack of Regulation**

In a recent newspaper article, Marco Nuti, Director of the Research Center for Innovative Biotechnology of the University of Padua and a European Community expert on biotechnology, complained that research is being hindered by the lack of a biotechnology regulatory agency or guidelines in Italy. This lack of authority and guidelines favors those who wish to genetically modify organisms. On the other hand, universities, government research laboratories, and serious industrial laboratories are disadvantaged because they lack regulatory guidance. Countries with appropriate biotechnology rules been able to release up to 140 transgenic organisms under well-controlled experimental conditions.

Nuti notes that a few years ago, the Universities of Catania and Padua, through genetic engineering, produced a mutant of *pseudomonas syringae* which reduced the quantity of an ice-forming protein. The mutant could be used to protect crops from frost. However, the attempt by the University of Catania to use this product to protect early crops of strawberries was prohibited by the Ministry of Agriculture and Forestry for lack of precise guidelines on the matter. Biotec Magazine had already published results on this research.

The bacterium *psuedomonas siringae* is a further example of the problems of biotechnology in Italy. The bacterium treated with x rays has been used in Italy under a Kodak (U.S.) patent to produce artificial snow in ski resorts. Beginning with an experiment in Verona, the bacterium is now under consideration for use in eliminating fog at airports. Nuti says it is possible that a small percentage of the many micro-organisms shot over mountain slopes remain unaffected by the x-ray treatment. Therefore, they might cause secondary effects to the environment. He suggests that the Ministry of Agriculture and Forestry should supply figures on its evaluation of the probability that some of the micro-organisms are not biologically inert.

One issue that Nuti says must be tackled in the future is the evaluation of risk for environmental introductions. He advocates a risk assessment for any release into the environment of genetically altered organisms.

**Italian Telecommunications Satellite Launch**

In January, the Italian Telecommunications Satellite (ITALSAT) was launched by Ariane together with the European communication satellite EUTELSAT II of Aerospatiale. In July after a break-in period, INTALSAT will be able to manage 12,000 telephone channels in addition to services like teleconferences, transmission of newspapers, texts, and TV programs. The ITALSAT I is expected to last in space for 5 years when it will be replaced by the technically updated ITALSAT II.

ITALSAT I was built by Italian industry (77 percent), European industry (16 percent), and American and Japanese industry (7 percent). The Italian Selenia Spazio was the prime contractor with the participation of AERITALIA, FIAR, LABEN, Siemens Telecommunications, BPD, and Galileo. The cost of ITALSAT came in under budget of 400 billion lire (about $347 million) as planned. Other costs must be added--100 billion lire for the launch cost, 30 billion lire for insurance, and 134 billion lire for the monitoring system.

The success of ITALSAT has prompted the Minister of University and Scientific Research, Antonio Ruberti, to say that the government is studying a possible fund for financing space commercialization. Credits will be offered for specific programs with large commercial fallout developed by industry. The fund, (the Ministers of Treasury and Budget agree) will be separate and additional to the financing given to the Italian Space Agency (ASI). The ASI has asked the government for 6,100 billion lire (about $5 billion) for the 5-year period, 1990-94.

**High-Speed Network for Scientific Data**

Since March 1990, Italy has operated a two-magabit network corresponding in Italian to the acronym GARR, uniting three pre-existing science and technology networks with three computing centers. The network includes most of the public and university laboratories in Italy and includes some industrial research establishments. The GARR network could be the most complete structure of this type in Europe and serve as a model for European Community-wide integration.

Organization for Economic Cooperation and Development Suggests Improvements for Italian Research and Development

The Organization for Economic Cooperation and Development (OECD) recommends that Italy increase the share of its GNP going to research and development (R&D), particularly the portion supplied by business enterprises, if it wishes to be competitive in the Europe that will emerge after 1992. The OECD also recommended that public research bodies and universities should be held more closely accountable for the results of their research spending and encouraged to produce quality. Among seven final recommendations, the OECD urged Italy to increase its research cooperation with the European Community (EC) and European Research Organization Agency (EUREKA). The OECD made six major recommendations.

1. Strengthen the evaluation of research in universities, public research establishments, state-owned industries, and government programs that aim at fostering R&D
2. Encourage the recruitment of young people to careers in scientific and technical professions
3. Develop cooperation with industry by creating transfer points, incubation centers, staff exchanges, and science parks
4. Develop special measures to encourage mobility of science and technology personnel between sectors and regions
5. Create a national authority for technology policy and increase the cooperation between universities, public research entities, and industry
6. Intensify international cooperation, particularly with European countries.

The OECD recommended increased focus and financial support for participation in EC and EUREKA programs.

**High Blood Pressure Drug Acts Against Cocaine Addiction**

Professor Gian Luigi Gessa, Director, Department of Neurosciences, University of Cagliari, has studied the effect of a drug called isradipina on reducing the effect of cocaine on mice. Isradipana blocks the introduction of calcium in neurons and the subsequent liberation of dopamine by cocaine. Dopamine is responsible for creating the gratifying sensations that produce the desire for cocaine intake. If treated with isradpina, mice that were trained to feed on cocaine lose interest in cocaine. Eventually they stop searching for cocaine altogether. Professor Gessa says that killing the stimulus for drug intake is extended also to heroine, amphetamines, and alcohol.

**Italian Research on Alzhimers Disease**

A group of Italian researchers of the National Research Council (NRC) directed by Professor Mario Brufani, Director, Institute of Pharmacological Chemistry, University of Rome, La Sapienza, have synthesized a new molecule with promising therapeutic effects for Alzheimers disease. Mediolanum Farmaceutici, a small pharmaceutical company, is cooperating in this research. The new molecule is called eptastigmina and derives from an alkaloid fisostigmin present in nature in an African plant. Eptastigmina is a lipophil inhibitor of acetylcholinesterase. The enzyme decomposes acetylcholine the disappearance of

acetylcholine from the brain and causes the onset of Alzheimers disease. The new molecule acts longer than other drugs, has greater penetration in the brain, and presents less dangerous side effects than other therapies used so far. Merck & Co. will market eptastigmina. A study team will be formed with Mediolanum Farmaceutici and the University of Rome to continue in the research of this promising new drug.

**Genetic Transplant Planned in Milan**

Professor Claudio Bordignon, Director, Hematology Service, S. Raffaele Hospital, Milan, will perform a genetic transplant on a 3-year old boy who is living in a sterile room because of congenital immunodeficiency. The boy's white blood cells have a defective gene that prevent the cells from defending against diseases. The boy, who lives in a sterile tent, is treated daily with a high dosage of a bovine enzyme that replaces the activity of his own white blood cells. Previously, Professor Bordignon froze over 1 billion white cells belonging to the boy and will treat them with a retrovirus that has been manipulated to make it harmless. The retrovirus will carry the gene that causes white blood cells to exert their activity for immunity. The retrovirus overcomes the barriers with which the white cell is protecting its DNA and inserts its genetic heritage into the DNA of the human cell. The results of the operation are uncertain in terms of the placement of the gene in the white blood cells. Also, consequences of the retrovirus in the human cell are unknown.

**Italy Reviews the 1978 Law on Mental Institutions**

In 1978 at the suggestion of the Psychiatrist Basaglia, the Italian Parliament passed a law that closed Italy's mental institutions. The mentally ill who were supposedly no longer dangerous were sent to their families. The law also provided for the creation of communities in which the mentally ill could live a better and more meaningful life. Apparently, the law has not been implemented. Structures and communities were never really organized except for a few sporadic cases. Also, families with patients living in their home sometimes suffered tragic consequences. Other mentally ill people were abandoned by their families. This increased the number of homeless people living on charity. The Minister of Health presented to Parliament a draft law that reintroduces mental institutions. The bill would enhance the authority of the physician to decree that a person must receive health treatment. This judgement does not require the consent of the patient, the patient's relatives, nor the city administration. The physician also may recommend mandatory institutional treatment for people as young as 14 (without parental consent). The draft law includes strict instructions for regional administrations to create mental hospitals and institutions according to new advanced psychiatric parameters and standards. Moreover, the draft law establishes a time limit for implementation after which the central government can intervene. The new draft law has already received much criticism and is expected to have a difficult life during Parliamentary discussions.

**Artificial Ears**

For the first time in Italy, a surgical operation was performed to attach two silicon ears to a 25-year-old man who was born without ears. The artificial ears are each connected to the bone by two 3.5-mm long titanium screws linked together with a small bar of titanium. A film of tatanium oxide causes the titanium to integrate with the bone. This prevents further interaction between the metal and the bone. The cost of the operation in Italy is 20 million lire (about $17,000).

**Suntan Lotions Under Scrutiny in Italy**

An alarm was raised by the results of a study conducted in Australia on the possibility that suntan lotions containing urocanic acid might cause skin cancer. Consequently, the Italian Minister of Health asked the National Institute of Health, Laboratory of Toxicology to evaluate the risk of using suntan lotions.

**Emission of Volatile Organic Compounds**

The National Research Council Institute of Perugia is conducting studies on volatile organic compounds emitted by plants that would be responsible for abnormal production of ozone at ground level, thus increasing the greenhouse effect. These compounds are mainly hydrocarbons, particularly isoprene. Isoprene is produced in oak, orange, and olive trees. This study would make it advisable to stop planting these trees for ornamental purposes in congested urban areas.

**Montefluos Company Purifies Surface Waters**

The Montefluos Company of the Ferruzzi Group has introduced a new method to purify river and lake water for drinking. The new technology using a hydrogen peroxide-base additive allows for the elimination of more than 50 percent of toxic substances in the form of halogenated organic compounds. The result of this treatment allows even poor quality water to be recycled for drinking use.

**Rome Public Urban Transportation--Environmentally Up to Date?**

Rome's public urban transportation management publicizes that for the last 3 years their buses have been using gasoil with three times less sulphur than established by European Community rules. All buses are periodically inspected with computerized systems for their emissions. Fifty-one buses are equipped with "emulsystem" to mix water and gasoil to decrease the emission fumes by 50 percent. Forty-two buses are equipped with a sophisticated ceramic filter that withholds carbon particles which are subsequently

burned at high temperature before being emitted into the atmosphere. Finally, the company is operating one line working entirely with an electric engine.

**Italian National Agency for Electricity Investing for Environment**

By 1995, the Italian National Agency for Electricity (ENEL) will invest for environmental protection 11,000 billion lire (about $9.65 billion), equal to 15 percent of the agency's 5-year budget. The ENEL is estimating that by 2000 there will be a great increase in demand for energy, while global atmospheric pollution is expected to be reduced by one half. The ENEL will use better quality fuel, study methods for reducing hazardous waste in the air, and build six desulphurization plants.

**Hazardous Waste Disposal**

In 1988, Italian hazardous waste was dumped in Africa, Lebanon, and South America, then shipped back to Italy on five ships. In January 1991, two advanced plants in Tuscany were opened for stocking and pretreating hazardous waste. Minister of Environment Giorgio Ruffolo said at the inauguration ceremony that to dispose safely of 12,000 tons of hazardous waste, the government spent in less than 3 years about 200 billion lire (about $175 million). This was about 12,000 lire/k of waste handled, against the commercial cost estimated at an average of 2-to-3,000 lire/kg. However, to complete the operation, it is estimated that about 80 billion more will be needed. Prototypes of plants have been created that will be used and duplicated in the future to prevent more Italian industrial waste from being secretly and unlawfully exported to developing countries. According to a European Community study, Italy should spend about 740 billion lire annually by 2000 to clean up completely approximately 20,000 sites where industrial waste has been illegally or unsafely dumped. However, the Minister of Environment said that in 3 years Italy should be able to legally dispose and treat all its urban and industrial waste. So far, Italy handles safely slightly more than 50 percent of its urban waste and slightly under 50 percent of its industrial waste.

**Automobile Battery Disposal**

The disposal of automobile batteries with the dispersion of lead in the environment has created a problem for Italian authorities. In early 1991, the government approved a regulation that increases the cost of the batteries by 1,900 lire (about $1.50). The extra cost will be collected by a consortium for the collection and disposal of spent batteries and lead residuals. The consortium consists of industry interested in recycling spent batteries, industry manufacturing batteries, and associations of artisans and collectors of spent batteries. The 1,900-lire tax is estimated to bring 17.5 billion lire to the consortium (two thirds of the operational cost). The remaining sum will be supplied by the recycling industry that will use spent batteries as raw material. In Italy each year, 180,000 tons of spent batteries are being dumped. Previously, only about 60-65 percent of these were properly disposed of, while the remaining 40-35 percent were dangerously dispersed into the environment.

**Adriatic Sea Mathematical Model**

In cooperation with the Venice National Institute for the Dynamics of Great Masses of the NRC, IBM Italia has created a mathematical model of the Adriatic Sea. The computer has sketched an idealized grid of 7 km per side squares and can compute within each square the speed of the marine currents, temperature, saline concentration, and presence of pollutants. The project will be expanded by the Ministry of Environment to a group including IBM Italia, Italian Agency for Nuclear and Renewable Energies (ENEA), Research Arm of the Italian Electricity Generating Board (CISE), IDROSER, and the Palomar and Pelagus Consortia. The group submitted a 3-year plan to analyze available models for the simulation of physical/chemical and biological processes occurring in the Adriatic basin, create a territorial information system to collect all available data to allow pertinent intervention in the environment, evaluate the interventions necessary for the recovery of the marine environment, and create a centralized environmental observation center.

**Atrazine in Drinking Water**

In May 1990, the Italian government made available 575 billion lire (about $500 million) to recover the atrazine-affected aqueducts to make water drinkable. However, several areas in Lombardy, Emilia/Romagna, Friuli, Marche, Piedmont, and Veneto did not accomplish the recovery. Consequently since mid-February 1991, about 450,000 Italian citizens do not have suitable drinking water. European Community directives establishing a maximum of atrazine of 0.1 g/liter have now been implemented. To avoid further worsening of the situation, the government has prohibited farmers from using atrazine. The atrazine must be replaced with other expensive products. The farmers complain about major costs, but a Green Party spokesman said that in the last 10 years by using atrazine, farmers have saved 80 billion lire. At the same time, the government spent 575 billion lire to clean up the damage caused to the drinking water supply.

**Fiat for the Environment**

Fiat signed an agreement with the Ministry of Environment to produce by January 1992 automobiles equipped with catalytic muffler. Fiat will invest about 2,646 billion lire (about $2.32 billion) in 3 years. Along with equipping automobiles with catalygic mufflers, they will research to further reduce automobile pollution, construct new manufacturing facilities, and construct heat cogeneration powerplants. For Fiat automobiles

already on the road, Fiat will sponsor the adoption of the "cromodora retrofit" manufactured by the Gilardini Company of the Fiat Group. This retrofit costs 1.2 million lire (about $1,000) and can decrease automobile pollution emissions by a minimum of 50 percent to a maximum of 80 percent. This is the first serious attempt to decrease the level of urban pollution caused by automobiles in the most congested urban areas.

**Magistrate Stops Oil-Fired Powerplant**

The Rovigo Magistrate has stopped the activity of the oil-fired powerplant of Porto Tolle located in the Po River delta. The reason is that ENEL has never obtained the permission from the regional administration to use the water of the Po River for cooling the plant. The plant produces 10 percent of Italian electricity and uses 80 cm/sec of the Po River water. This raises the river's temperature by 7-8°C to between 37 and 40°C. In addition, the powerplant annually discharges into the atmosphere through its chimney about 137,000 tons of sulphur dioxide. The powerplant also dumps a great quantity of chlorides into a discharge canal 5-km long and 5-m deep that ENEL dug to return the water to the Po River. The destiny of the powerplant is now in the hands of the Rovigo Magistrate and in the results of the analysis of the water conducted by the University of Padua. The action of the Magistrate was also inspired by the fishermen of the region, who complained that the hot water dumped by the plant was killing the area's shellfish. The Greens also took this occasion to reiterate to the Minister of Environment the request to make the area of the Po Delta a natural park. Enforcing strict environmental protection sometimes (as in this case) reflects negatively on the already precarious situation of the energy supply in Italy.

**Dumping Hazardous Waste in Naples Area**

Regional and central government authorities have discovered 34,000 k of hazardous waste dumped in the Naples area. Also, in a Naples railway station a freight train was seized filled with 2,500 tons of varnish industrial waste. Both cargoes were directed to the Naples area from northern Italy, conflicting with government regulations. The regulations call for hazardous waste to be treated and disposed of in the same region where it is produced. Authorities have estimated that the business would have bought to the local Mafia several million lire. The government is keeping under surveillance the illegal dumping areas in the Naples area to detect presence of dioxin.

**Noise Pollution Abatement**

In March 1991, the government approved a decree setting up new limits for noise. During daylight, the maximum allowed will be 70 decibels (DB) in industrial zones, 65 DB in zones with intense human activity, 60 DB in zones of mixed human and industrial activity, 55 DB in residential areas, and 50 DB in special protected zones like hospitals, schools, and parks. During the night hours, the limits are 60, 55, 50, 45, and 40, respectively. The weak point of the decree is that noise-polluting industry has 5 years to recondition its plants to make them less noisy or to relocate. At the same time, control of noise in urban areas caused mostly by traffic will be governed by regulations to be issued by regional administrations. Normally, regions are not very prompt in following government decrees. Therefore, several years will pass before the government rules will be properly implemented.

**AIDS Update**

**New Test for Pregnant Women.** Researchers of the two Rome universities and Padua University, in cooperation with researchers of the Karolinska Institute of Stockholm, have devised a new test for serum positive pregnant women. The presence of an antibody in the serum of the pregnant woman revealed by the test is a guarantee that the child will be born without being serum positive. The test is expected to have a marginal error of 1 percent and is supposed to be available for use soon in hospitals and clinics.

**Fast Test to Identify the Presence of HIV.** Professor Guido Norbiato (endocrinology service, Sacco Hospital, Milan) is performing a test that reveals the presence of HIV in blood only 6 hours after the patient was presumably infected. The test is performed on 5 cm of blood through the polymerase chain reaction technique which consists of amplifying millions of times a DNA fragment extracted from the white blood cells. The amplification of a DNA sequence allows the identification, even in a very small quantity, of the HIV genoma if it has entered and was integrated into the DNA of the white blood cell. This test would allow for immediate therapy of the infected person right after a suspected infection occurred with advantages for the timely treatment of the disease.

**Transplant of Medullary Cells.** Licinio Contu, Professor of Medical Genetics, University of Cagliari, has announced that a 29-year-old girl with AIDS who in May 1990 underwent surgery for a transplant of medullary cells, is steadily recovering and gaining weight and was sent home from the hospital for over a month. Currently, she is back in the hospital, but she is not kept in a sterile room and is instead allowed to conduct a normal patient life within the hospital. To date, the Cagliari case has the longest survival time in all cases that underwent the same surgical treatment elsewhere in the world.

**Mandatory AIDS Test for Army and Police Personnel.** The law states that army, police, and firemen corps recruits may have an AIDS test only if the individual consents. No disciplinary measures may be taken against anyone who refuses the test.

**1991 AIDS Prevention Campaign.** The government is launching the third information campaign on AIDS directed especially towards women in child-bearing years, adolescents, homosexuals, and bisexuals. The National Committee on AIDS has given the task of the new campaign to five publicity and five public relations agencies in Italy. The campaign will focus on the importance of undergoing an AIDS test for the timely cure of the disease. For information, callers may use the "green telephone" line. Much material will be distributed free in schools, and special pamphlets will be inserted in records and tapes of popular music. Special warnings and information will be included in sanitary pads for women. For homosexuals, the campaign will center on gay magazines and periodicals.

**Free Distribution of Syringes.** The city of Modena has put into operation a special automatic distributor of syringes. The used syringe is introduced into a slot of the dispenser and a free new syringe in made available. This experimental method was devised by the city administration with the intent to limit the propagation of the disease among drug addicts through infected syringes. The same system will also operate soon in Rome where the city administration has allotted 2 billion lire (about $1.7 million) to provide syringe dispensers in pharmacies and streets. Money also will be used to equip special automobiles that will tour the critical points of the drug use area to dispense free syringes.

**Lesson on AIDS in Jail.** During November 1990, several physicians participating in the Milan seminar "Milano-Medicina" held lessons on AIDS for 200 convicts of the Milanese jail of "San Vittore."

**Health Authorities Control Barber Shops.** An investigation conducted by the local health unit of the center of Rome revealed that only 40 percent of the barbers were following the sterilization rules required for handling of their instruments. However, Professor Visco, Rome Infectious Diseases Hospital, said that in medical literature, there have been no reported cases of AIDS being transmitted through barbers' scissors even in the presence of blood.

**Other AIDS News.** The National Institute of Health is offering 150 fellowships to Italian postgraduates with at least 1 year of experience in AIDS research. Italian institutions will be provided with 25 million lire (about $21,000) per year for 120 fellowships. Of those fellowships, 30 are reserved for institutions and research centers abroad with a financial support of 50 million lire per year.

The Minister of Health announced on December 1990 that a monthly magazine will soon be published and called "Giornale Italiano Dell AIDS - Italian AIDS Journal." The journal will review the medical, psychological, and social aspects of the disease and will provide information related to medical assistance, pertinent legislation, and scientific progress in AIDS research.

**Italian Program for Antarctica**

The sixth Italian campaign for Antarctica still in progress is costing the Italian government 57 billion lire (about $50.9 million). However, the Minister for University and Scientific Research has presented a draft law to the Parliament to allocate 390 billion lire for Antarctic expeditions in the 5-year period 1991-95. Approximately 200 billion lire will be used to build and outfit a highly automated winter station that is expected to be in full operation for the 1996-97 season.

**Postgraduate School of Materials Science**

A postgraduate school was recently inaugurated in Rome for materials science organized by the Interuniversity Consortium of Physics of Matter (INFM). The courses, which admit 50 students from university and industry, lasts 2 weeks and require a tuition of 200,000 lire (about $190). The school is focusing on the review of all innovative materials.

**Plastic Made from Starch**

Ferruzzi Ricerca and Tecnologia (FERTEC) of Novara has patented a new type of plastic that is biodegradable like paper. The new compound called "MATER-BI" is composed of cornstarch and a water absorbent oxygenated polymer of low molecular weight. Previously producing 5,000 tons annually, FERTEC is expected to increase the production to 15,000 tons in 1991. According to a market survey, annual production of 100,000 tons could be commercially marketed by 1995-96.

**New Consortium for Nuclear Reactors**

Ansaldo, Fiat, and ABB Atom (Sweden) have formed a consortium to study and a prototype intrinsically safe nuclear reactor called "PIUS." The innovative concept for PIUS is that if some component is defective, the reactor will stop working on its own and not require human intervention. ABB Atoms has vast experience on construction of BWR and PWR reactors. Fiat and Ansaldo have formed an additional consortium with the Italian companies Belleli and TECHINT to prepare for the new technologies to be implemented.

**Ansaldo in Southern Italy**

Ansaldo is investing 60 billion lire in 1991 to create research centers in southern Italy. The first center (10 billion lire) is located near Bari and will focus its activity on innovative systems for combustion. The other center (50 billion lire) is located near Naples and will conduct research on superconducting materials and automated urban transportation with special emphasis on environmental protection. Ansaldo plans to invest 116 billion lire (about $103 million).

**Radio Frequency Ionization Thruster Assembly Tested**

The Italian company Fiat and the German MBB/DASA have developed jointly a radio frequency ionization thruster assembly (RITA) to obtain a propulsion and control system of reduced size and high power. RITA was recently tested successfully at Giessen, Federal Republic of Germany. The system will be used for telecommunications satellites and interplanetary probes for its capability to generate a specific impulse ten times stronger than that generated by traditional thrusters with chemical propellent. Soaring Costs for the Trieste Synchrotron.

The synchrotron light source under construction in the Trieste research area has already obtained 35 billion lire of the total 150 billion estimated for the project. However, a recent cost revision has shown the need of 160 billion (about $136 million) more to complete the syncrotron. The NRC will provide 75 billion, while the government, the regional administration, by the Trieste research area will provide the remaining 85 billion.

**Photovoltaic Projects**

The ENEA and ENEL are concentrating on research for developing photovoltaic energy. The ENEA has inaugurated at Portici near Naples a center exclusively dedicated to photovoltaic research. When completed at the end of 1991, the new center will cost over 200 billion lire (about $180 million). The center will focus especially on raising the efficiency of amorphous silicon cells from the present 5 percent to at least 10 percent output. During 1991, the ENEA will also upgrade the 300-kW Delphos Photovoltaic Powerplant to 600 kW. The ENEA and ENEL will cooperate in the next 5 years with joint research projects on photovoltaic research with a total investment of 350 billion lire (about $31.8 million). In the next 2 years, ENEL will build a 3.3-MW photovoltaic powerplant in the Naples region. During this same time, ENEL also will transform the passive solar powerplant of Adrano in Sicily to a photovoltaic plant.

**Gallex Experiment**

Professor Nicola Cabibbo, President, INFN, announced the beginning of the Gallex Experiment in the Gran Sasso Laboratories. Intended to capture and reveal the presence of neutrinos, the Gallex Experiment took 4 years of preparations with the participation and joint efforts of Italy, the FRG, France, Israel, and the U.S. and is expected to last 5 years. The experiment is located in gallery "A" (the westernmost gallery of the laboratory) under 1,500 m of rocks. The gallery is partially occupied by a tank containing 30 tons of Gallium 71 in solution as Gallium Chloride (GaCl). When a nucleus of Gallium 71 is hit by a neutrino, a neutron is expelled and Germanium 71 is obtained. Germanium 71 is an isotope with an average duration of 11 days. After this period, it captures an electron and is again transformed into Gallium with the emission of a low x radiation. Every 3 weeks, the researchers will extract from the tank containing GaCl the few atoms of Germanium 71. Through an x-ray counter, they will detect their emissions when they are reconverted into gallium and (through statistical computation) establish the number of neutrinos that have interacted.

## Spain

*For further information on Spain items, contact Leroy C. Simpkins, Office of Science Attaché, American Embassy, Madrid, APO New York 09285*

**Biology in Barcelona, Spain**

By many estimates the biosciences are the brightest part of Spain's science and technology spectrum, and they have one of the longest traditions of any scientific discipline in Spain. This background led to two Nobel Prizes in physiology or medicine for Spain. Those prizes have stimulated further work.

The centers visited were the Centro de Investigacion y Desarrollo (CID) and the Joint Unit of Biochemical Engineering. Each is located at a university complex: the first near Barcelona University and Barcelona Polytechnic University, and the second on the grounds of the Autonomous University of Barcelona.

Most of the students working with the professional staff of the centers are from the Barcelona area and attend one of the three universities. The enrollments at the three universities are: Barcelona University - 70,000, the Polytechnic - 30,000, and the Autonomous University of Barcelona - 30,000.

Barcelona, with 2 million inhabitants, is also capital of the Autonomous Region of Catalonia, an area with a long history and its own language--Catalan. Most courses at the three universities are taught in Catalan, and the occasional student from elsewhere must learn the language to understand the lectures.

**Center for Research and Development**

The CID is one of the national research centers operated by the Superior Council for Scientific Research (Consejo Superior de Investigaciones Cientificas [CSIC]). The CID is devoted almost exclusively to biology. The current Director is Juan Albaiges Riera, an organic chemist whose interest in petroleum eventually led him to environmental chemistry. He has worked at Cal-Berkeley and Woods Hole. The CID is still in contact with them, along with Scripps, MIT, and Cal-Davis.

Some 6 years ago, Albaiges began to reforge the CID into a new, interdisciplinary unit focusing on bio-organic chemistry, biotechnology, and biomedicine. The staff is used in new ways to complement the new programs and additional scientists. Albaiges estimates that the transformation of the CID will not be complete for 2 years or more.

Three main groups of 20 staff and 30 students, both graduate and postdoctoral, receive the support of a 50-person management and service group. Albaiges points out that CID is the first CSIC center to have a manager responsible for operations as well as a director responsible for the scientific program.

Each research group at the CID has three departments. The bio-organic chemistry group includes bio-organic chemistry, environmental chemistry, and halogenated materials. Work in bio-organic chemistry centers on pest control using behavior modification. The work also includes studies of sexual pheromones of the Mediterranean pine moth aimed at reducing and controlling. Research in environmental chemistry looks at management of natural and introduced contaminants and toxins in coastal zones. Albaiges is active in this department. Research in the halogenated materials department (soon to move to the institute of materials science) examines polychlorinated compounds, free radicals, and polymeric semiconductors.

As is usual in CSIC centers, the council pays staff salaries and infrastructure costs. Researchers seek funds to carry out the actual work. Each project is charged 15 percent overhead, which goes to the management and services division to cover operating expenses. Albaiges ranked the sources of funds in three classes (from easiest to hardest accessibility):

- *National Science Plan funds*
- EC, NATO, European Science Foundation, and foreign government agencies
- Private sources.

The director said it is very difficult to run a center like his, trying to reach international levels of work with the resources available. Large grants are easy to obtain, but are insufficient to support world-class research. The CID's total budget is about $10 million. The ratio of $6 million for project funds to $4 million for salaries is unusually high. Typically, a center with a $4-million salary budget would have a project total of $1 to $1.3 million in addition. Forty percent of the CID budget comes from private sources, which is a good indication of the relevance of its work (10 percent is a more common figure at other centers). The CID has 15 EC-funded projects which is 10 percent of all such projects in all fields in Spain.

The CID's publication record shows that the director is having some success in attracting extra funds and reaching international performance levels. The professional staff of 60, together with 90 students, publish 80 research papers annually in international journals where they are subject to peer evaluation before acceptance.

**Blood Pump for Children's Surgery**

A group of Italian researchers from the Bergamo Hospital, the Department of Bio Engineering of the University of Milan, and the Milan company BELLCO (Fiat Group) have devised a blood pump to be used in cardiopulmonary surgery for children. The pump lowers the risk of mortality during the surgery from 26 percent to 10.5 percent. Also, the postsurgical intensive care period is 2 days rather than the customary 4 or 5 days. The new pump simulates the blood wave in the children's arteries through using a single tube as would be done normally by the heart. The method is only applicable to children who require only 1/1.5 liters of blood/min. The method would not work for adults who require 4/5 liters/min. The pump is called "pulsamatic" and is presently being tested successfully in the Bergamo Hospital and at the London Harefield Hospital. The pump is not yet being produced industrially, but it is estimated that it will cost between 50 and 70 million lire (between $45,000 and 63,000). In Italy alone, the cases of pediatric cardiosurgery are about 1,000/ year.

**Italian Participation in High-Definition TV**

Within the framework of the Eureka 95 Project, the French (Thompson) and the Dutch (Philips) recently presented the super TV set of Europe. This TV adopts the D2 MAC System intended to replace the PAL and SECAM systems and to act as an intermediate stage for the introduction of the high-definition television (HDTV). Italian industry's contribution to the manufacturing of this set may be estimated at around 30 percent. Italian industry participated through the Italian Consortium for the Development of European High Definition (CISAE) with companies like SELECO for the video technology, Selenia and TELETTRA for telecommunications, SGS-Thompson for electronic components, and the Italian National Broadcasting Company (RAI) for diffusion. The European HDTV Eureka 95 Project is aiming to have ready by 1995 a TV set originating from the just-introduced super TV set, operating with 1,250 high definition lines with the D2 MAC System. The initiative is intended mainly to block the market for new HDTV sets by Japanese Technology. Recent research conducted in the same area by MIT and the U.S. company General Instruments is threatening the validity of the European D2 MAC System.

**Safe Nuclear Research**

The present energy crunch in Italy is focusing attention on nuclear energy after the popular referendum of 1987 canceled all Italian efforts in this area. The National Council on Economy and Labor drafted a document for the government reaffirming the necessity to look at safe nuclear energy as a way to overcome the energy crisis. To respond to many of these requests coming from both politicians and industry, the ENEA and the ENEL started a joint research effort on intrinsically safe reactors with an initial capital of 10 billion lire (about $9 million). The manager of Ansaldo, the company that was impacted by the abrogation of nuclear energy in Italy, said that Ansaldo lost 1,000 billion lire after the referendum decision. Nevertheless, Ansaldo managed to keep an up-to-date selected team of scientists and technicians that would be ready to continue immediately the tradition of nuclear research in Italy if the Parliament would act amending the referendum results.

**Cows to Become Pharmaceutical Laboratories**

Professor Vittorio Bottazzi, Director of the Institute of Microbiology, University of Piacenza, inaugurated the Pizcenza Center (Center), a biotechnology center. The Center is financed by the university, NRC, the European Community, and private industry. The main aim is to produce, through genetic engineering, cows milk containing proteins with a pharmacological effect like insulin, interleukina, coagulation factor, etc. Proteins produced in the milk will be extracted by pharmaceutical companies interested in obtaining specific proteins produced biosynthetically by the cow. The project is based on studies conducted in Great Britain where mice have been genetically manipulated to produce a type of lactoglobuline in their milk.

In another project, the Center has isolated some intestinal bacteria that during their growth are absorbing cholesterol. The Center is studying the inclusion of these bacteria in nutritional products like yogurt and milk to combat cholesterol. Finally, the Center has also isolated and manipulated some lactobacilli to combat pathogenic germs that infect the vagina.

**Lagging High-Speed Railway Project to be Privatized**

The new management of the Italian railway and the Parliament have decided to open to private business the high-speed lines in which Italy is remarkably behind countries like France and the FRG. The first two lines to become high speed will be the Naples-Milan and the Turin-Trieste in a period of 5-7 years. The financing will be provided by the FINAV Company belonging more than 50 percent to the state railway and the rest will be provided by private investments and share holders. Two French banks (Credit Lyonnais and the Indosuez Bank) plus Italian banks have already joined FINAV. The operation of the project will be the responsibility of the TAV (TRA/TE Alta Velocita high-speed lines) organization which will manage the 25,000 billion lire financing (about $20 billion) of which $10,500 will be spent in 1992.

**Joint Biochemical Engineering Unit, Department of Chemistry, Chemical Engineering Unit, Autonomous University of Barcelona**

This biological research center, conveniently abbreviated JBEU, affords an interesting contrast with CID, for it is part of the Autonomous University and is operated jointly by the university and CSIC. The organization and focus are more oriented toward teaching. The university parent chemistry department is made up of units of analytic, physical, inorganic, and organic chemistry, plus one on chemical engineering that operates JBEU as a subunit for biochemical engineering. The director is Carlos Sola Ferrando, a Catalan who performed postdoctoral R&D in Toulouse.

The teaching/research unit consists of 15 professors, 1 researcher, 8 grantees, and 3 support persons. The unit prepares students for advanced degrees in biotechnology, cooperating mainly with the departments of biochemistry and molecular biology outside the chemistry department. The annual project budget is $300,000; salaries paid by the university and CSIC are in addition. Main areas of interest described during the visit are

1. Enzymes in organic media
- Peptides and enzymes (collaboration with University of Texas, University of Colorado, and Cal-Berkeley).
2. Biological decomposition of toxic compounds
- Treatment of waste water by anaerobic methods
- Use of fungi
- Special attention to paper industry.
3. Immobilized biocatalysts and antibiotic production
- Fermentation
- Antibiotics
- Use of porous microspheres to hold microorganisms
- Champagne industry support (collaboration with Oak Ridge, Cal-Berkeley)
- Computer control of biotechnological processes
- Efficiency of fermentation and waste treatment
- Demand cycle
- Automation.
4. Downstream processes
- Separation and purification of waste water
- Anaerobic treatment
- Phenols
- Dioxins
- Ionic exchange columns
- Pure enzymes
- RNA
- Chromatography
- Lipase purification.

The Autonomous University publishes an annual research report. Although it is in Catalan, bibliographies of published papers contain mostly English titles. Access to information on university chemistry research, including bioengineering, is also available via BITNET: IQUI0 @EBCCUAB1. (IQUI0 ends with a "zero"; second term begins with the @ sign and ends with a "one")

## Indonesia

*For further information on Indonesian items, contact USDAO, American Embassy (Jakarta), Box 1, APO San Francisco 96356.*

**Indonesian Seminar on National Industrial Biotechnology**

On March 4-5, 1991, the Agency for the Assessment and Application of Technology (BPPT) held a seminar on national industrial biotechnology. The seminar focused on the opportunities to utilize biotechnology in promoting Indonesia's industrial development. Topics included a range of biotechnology products such as ethanol, antibiotics, amino acids, and enzymes. Also discussed were marketing and investing prospects. Domestic participants included representatives from BPPT, the Department of Trade, the Indonesian Chamber of Commerce (KADIN), Indonesian Investment Board (BKPM), Technical Institute of Bandung (ITB), Taiwan, Japan, the European Community (EC), the Federal Republic of Germany, Denmark, France, Italy, and the Netherlands.

In an effort to promote utilizing biotechnology in Indonesia's industrial development, BPPT hosted a concurrent seminar on national industrial biotechnology at the Jakarta Hilton International Hotel. The agenda included

- Biotechnology development worldwide and in Indonesia
- Marketing prospects for industrial biotechnology products
- Banking support for bioindustry investment in Indonesia.

Indonesia is well endowed in biomass resources and rich in biodiversity. The BPPT is responsible for selecting the appropriate applications of biotechnology for Indonesia's industrial development program as well as applications in medicine, agriculture, and forestry. The BPPT is interested in obtaining information about the current stage of development of international biotechnology. There is also enormous interest in the prospects for private sector investment in developing the domestic market for industrial biotechnology products in Indonesia. The BPPT is also attempting to foster better communications between foreign biotechnology experts and the Indonesian private sector.

**CHANGE REQUEST**
NAVEURONR-5605/1 (Rev. 3-85)

## FOR YOUR CONVENIENCE . . .

Government regulations require up-to-date distribution lists for all periodicals. This form is provided for your convenience to indicate changes or corrections. If a change in our mailing lists should be made, or if you want any of the ONRL publications abstracted in this issue and listed below, please check the appropriate boxes. Fold on dotted lines, being sure our address is on the outside, tape or staple the lower edge together, and mail.

1. ☐ CHANGE OR CORRECT MY ADDRESS EFFECTIVE IMMEDIATELY OR (date)
2. ☐ DELETE MY NAME FROM DISTRIBUTION LIST
3. ☐ PLEASE SEND ME THE FOLLOWING ONRL PUBLICATIONS

Corrected or New Address

**Reports**

- ☐ 91-1-C
- ☐
- ☐
- ☐
- ☐

**MAS Bulletins**

- ☐ 05-91
- ☐ 04-91
- ☐ 03-91
- ☐ 02-91
- ☐ 01-91
- ☐

Fold Here

Fold Here

FROM:

_____

_____

_____

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

**BUSINESS REPLY MAIL**
FIRST CLASS PERMIT NO 12503 WASHINGTON DC

POSTAGE WILL BE PAID BY DEPARTMENT OF THE NAVY

Commanding Officer
Office of Naval Research, European Office
Box 39
FPO New York 09510-0700